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Study the Thermal Conductivity Enhancement of different size Cr Nanofluids

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Abstract: Fluids with suspension of nanoparticles are called nanofluids, and usually they have greater thermal conductivity compared to their base fluid. The enhancement of thermal conductivity depends on many factors such as the suspension of Metallic Cr nanoparticles on base fluid for the preparation of nanofluids. Transitory hot wire device has been constructed and calibrated then used to measure the thermal conductivity of Cr nanofluid for different size, volume factions and base fluids. Heat conductivities of nanofluid is inversely affected by the size of nanoparticles. The comparisons of the ratios of heat conductivities for varying nanoparticles size were performed. The maximum thermal conductivity ratio is 1.245 for 75nm and volume fraction 1%.

Keywords: Nanofluids, Chromium nanofluid, thermal conductivity, THW

I. INTRODUCTION

The purpose of using nanofluid instead of conventional fluid is the low thermal conductivity of conventional fluid. It's important to increase the thermal conductivity of working fluid to enhance the efficiency of thermal application devices. The first measurement of the thermal conductivity of nanofluid has been presented [1]. Enhancements in heat conductivities for metallic as well as other nanoparticles suspension in base fluids were previously determined [2]. A Ag and Au particles of nanometre size suspended in H2O base fluids and toluene media were used to measure thermal conductivity using Transitory hot wire technique (Patel et al. 2003)[3]. The data obtained showed that for temperatures ranging from 30 to 60oC at a loading of 0.000 26, the enhancement in heat conductivity was 5% –21%.

Minute quantity of diamond (UDD), silver and silica particles of nanometer size were dispersed on the base fluids and the enhancements in heat conductivities of the nanofluids utilising transitory hot wire technique has also been previously investigated [4]. Superior results correlations were obtained when compared with Hamilton-Crosser model with an efficient volume fractions of particles of nanometer size correlations for heat conductivities. Procedures for the preparation of nanofluids that involved suspensions comprising of nano-phase powders and base fluids have been previously presented [5]. The photomicrographs of their TEM were presented to in order to demonstrate the steadiness and uniformity of the suspensions. The hot-wire device was employed for the determination of the heat conductivities of Cu nanofluid.

The transitory hot wire (THW) technique has been employed in the determination of heat conductivities of Al2O3, TiO2, WO3 and Fe fluids containing nanoparticles that were investigated and compared with one another (Dae-Hwang et al.,2007)[6]. The preparations for the fluids containing nanoparticles were carried out in a 2-step method by scattering the particles of nanometre size in the base fluids. The wire was employed both as a heater as well as a thermometer. The THW technique determines the temperatures and time responses of the wire to sudden electrical

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pulsation. The fluids containing nanoparticle samples demonstrated great enhancements in heat conductivities in comparison to their base fluids, owing to the clustering of the particles of nanometre size in the fluids which was deliberated in the said investigation that is beyond the hypothetical expectancy of dual-component combination system.
Comparison between several techniques of heat conductivity determination including the stable- state parallel-plate method, the temperature oscillation method and transitory hot-wire technique was conducted and found that the transitory hot wire technique has been most extensively employed [7]. However, it is not easy to directly use the conventional hot wire method in view of the fact that generally, fluids containing nanoparticles are electrical conductors. An improved hot wire cell was previously suggested [8] by galvanising the hot wire with epoxy adhesive which are exceptional electrical insulator and heat transmission was suggested to be employed. The effects of sizes of metallic particles of nanometre size suspension on ethylene glycol has also been investigated [8], and presented single model for heat conductivities of nanofluid containing varying sizes of metallic particles of nanometre size. Comparison of the data generated from the experiment with the model provides evidence that the decline in heat conductivities of solids with size of the particle has to be recognised, especially when building models for heat conductivities of fluids containing nanoparticles.
Heat conductivities and heat diffusivity of Cr particles of nanometre size suspension in H2O base fluid utilising one step technique at varying volume fractions has been previously investigated [9]. The hot wire-laser beam refraction technique was employed to determine the heat conductivities and heat diffusivity. The data obtained demonstrated that the heat conductivities and thermal diffusivity of fluids containing nanoparticles increase with increase in nanoparticle concentrations in the base fluids. In the present study, a new data set for heat conductivities of Cr nanofluids with nanoparticles of different particles size suspended in different base fluid, and for variations of volume fractions was measured utilising modified transitory coated hot wire technique.

II. PREPARATION OF NANOFLUIDS

The preparation of nanofluid is a prerequisite for the determination of heat conductivities of nanofluids and evaluation of the variables that effect on it such as nanoparticles volume fraction, nanoparticles size, and base fluid. The one-step method technique were employed for the preparation of the samples of the nanofluids. The Cr metallic particles of nanometre size (30, 50, 80 nm) were suspended in DH2O and ethylene glycol at varying concentrations (0.2, 0.4, 0.6, 0.8 and 1%). An ultrasonic was employed for 10 hours in order to guarantee appropriate mixture and dispersal of the particles of nanometre size unto the base fluids. Sediments were not found up to 24 hours post onset. As the surfactant induced alterations in the characteristics of the nanofluids, it was not employed. Figure 1 show the Transmission Electron Microscope (TEM) images of the 30 nm, 75nm Cr nanoparticles suspended on DH2O and EG at 0.8% volume fraction.

III. HEAT CONDUCTIVITY MEASUREMENT

The transitory hot wire sensor technique is extensively employed in the determination of heat conductivities of liquid as well as gas. In the past 20 years, studies of heat characteristics of solids subjected to pressure have been developed. The cell used in the experiment comprises of wire which is enclosed by media whose heat characteristics were to be measured. The Transitory Hot Wire method for the determination of heat conductivities in fluid is centred on detecting the temporary rise of temperature in a thin wire submerged in the material to be tested, at heat equilibrium in the initial stage, subsequent to the supply of a step-by-step electrical current. The 100 micro meters coated by Teflon wire made from Platinum acted as source of heat and yield time dependent temperatures, inside the material to be tested. Hypothetical models [12-16] that describe the transitory hot wire method is a derivative of the systematic solutions of the thermal transmission equations for line thermal source of radius r0 and length l1 of insignificant heat mass, that is precisely surrounded, having no resistance to heat contact, in an unrestrained thermal sink, at even temperatures T0 at the initial stage. This sink was recognised of having standardised and isotropic materials with fixed thermal transmission characteristics. Once a fixed electric current is supplied in a stepwise manner, the wire promptly and completely releases the source of heat yield per unit length, q, to the sample to be tested, where it will be transferred outward and kept exclusively. The increase in temperature at the radial distance r from the thermal source is expressed in equation (1).

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$$\Delta T(r,t) = \frac{q}{4\pi k} \ln \frac{t2}{t1} \qquad (1)$$

Where T is the determined temperatures of the nanofluids, K is the heat conductivities of the nanofluids, t is the time for the increment to increase the temperature, r is the radius of the wire, and q is the current applied via the hot wire. Further facts on the equipment used and the technique employed could be obtained somewhere else [10]. For the procedures used in this experiment, the wire is heated through a fixed electric current applied at step time t. An increase in the temperature of the wire is measured through its resistance alterations that could be determined in time with the used of Wheatstone-bridge circuit. Subsequently, heat conductivities is derived using Equation 1, giving the heat flux q. To verification the measuring device, the measurement of the thermal conductivity DH2O and ethylene glycol at 25C were conducted. And it was found within the standard date [11] for H2O with estimated error of 2%. Each experiment was replicated 10 times for all samples and conditions, hence the data presented in this study are representations of the mean of ten replicates at errors estimated at ±3%.

IV. RESULTS AND DISCUSSION

In this investigation, several samples of nanofluids with unidentified heat characteristics were determined using transitory hot wire technique. The evaluated samples of nanofluids were Cr in distilled H2O with three nanoparticles size (30, 50, 75) and five volume fractions (0.2%, 0.4%,0.6%, 0.8%, 1%), Cr in ethylene glycol (EG) for the same sequence as in H2O. The ratios of heat conductivities of different nanoparticle size of Cr nanofluid, heat conductivities of distilled H2O base fluids, as well as range of volume fractions are listed in table 1, where the higher enhancement ratios of heat conductivities is 1.120 at 75nm size and volume fraction 1%. Table 2 list the ratios of heat conductivities of Cr nanoparticles with different size suspended on ethylene glycol. The higher thermal conductivity ratio obtained on volume fraction 1% is 1.42. These increments increase in thermal conductivity because as thermal transmission via solid to fluid suspensions occur at the interface between the particle and the liquid, a rise in the interfacial region could result to further improvement in the efficiency of thermal transmission characteristics.

Figure 3 depicts comparison between thermal conductivity ratio of 30nm Cr particles of nanometre size suspension in DH2O for present work and Faris et.Al. with 36nm particle size for range of volume fractions. In addition, the Ref.[9] use the optical transitory hot wire method.

Effects of the size of nanoparticles on the enhancement ratios for the range of volume fraction was presented in figure 4. The ratios of heat conductivities rise with rise in the size of Cr nanoparticles and also still increase with increase in volume fractions of particles of nanometre size.

The heat conductivity ratio changes with variation of volume fraction for range of nanoparticles size for Cr suspended in ethylene glycol as presented in Figure 5. The thermal conductivity ratio is greater compared to the identical data with water base fluid and this is because the heat conductivities of H2O is greater compared to those of ethylene glycol. Its mean the nanoparticle will enhance thermal conductivity better for lower heat conductivities of base fluids. Although, the effect of nanoparticle size appear more functional for base fluid has higher heat conductivity as in H2O.

V. CONCLUSIONS

The heat conductivities of Cr nanoparticles was determined utilising coated transitory hot wire technique. The effect of three nanoparticle size was investigated for five volume fractions and different base fluid. Analysis of the data

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generated corroborate with the findings of the study conducted by Faris Moh. At el. [9]. The heat conductivity increases with increase in volume fraction, even though, increase in metallic nanoparticle size will induce an increase in the heat conductivities of the nanofluids.

Abbreviations

EG	ethylene glycol
THW	transient hot wire
TEM	Transmission Electron Microscope

Table 1: Thermal conductivity of Cr nanofluid with different base fluid and nanoparticles size at temperature 20c.

Volume fraction	Base fluid water	30 nm Cr & water	50 nm Cr &water	75nm Cr &water
0.2	0.607	1.041	1.05	1.070
0.4	0.607	1.052	1.066	1.088
0.6	0.607	1.062	1.078	1.103
0.8	0.607	1.074	1.088	1.110
1	0.607	1.0801	1.101	1.120

Table 2: Thermal conductivity of 80nm Cr nanoparticles suspended on the water for the range of temperature

Volume fraction	K for EG	K ratio 30nmCr	K ratio 50nmCr	Kratio 75nm cr
0.2	0.2473	1.23	1.3	1.30
0.4	0.2473	1.27	1.39	1.39
0.6	0.2473	1.32	1.45	1.45
0.8	0.2473	1.42	1.49	1.49
1	0.2473	1.42	1.50	1.50

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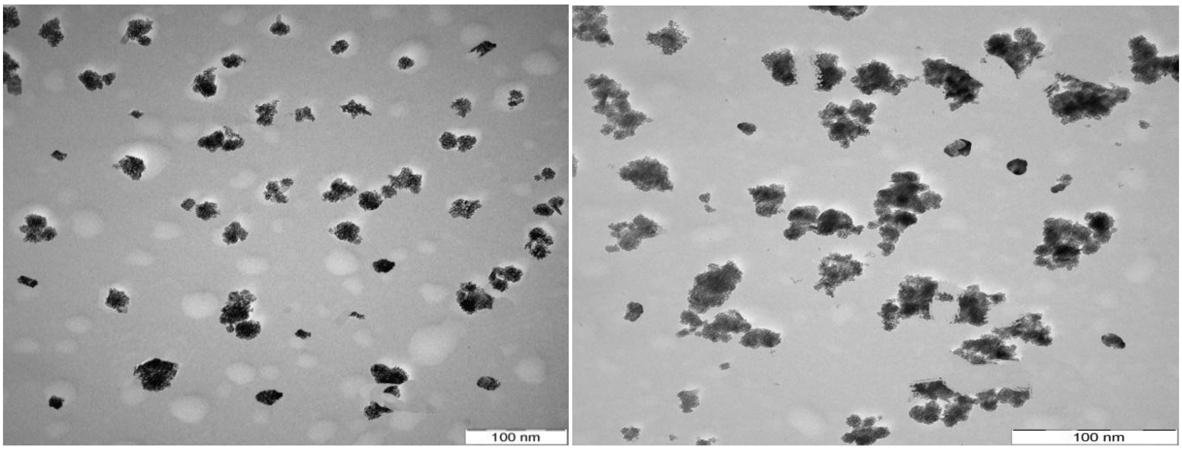

(a) (b)

Figure 1: shows the TEM of (a) 30 nm Cr suspended in water for volume fraction 0.8% (b) 75 nm suspended on EG for volume fraction 0.8%.

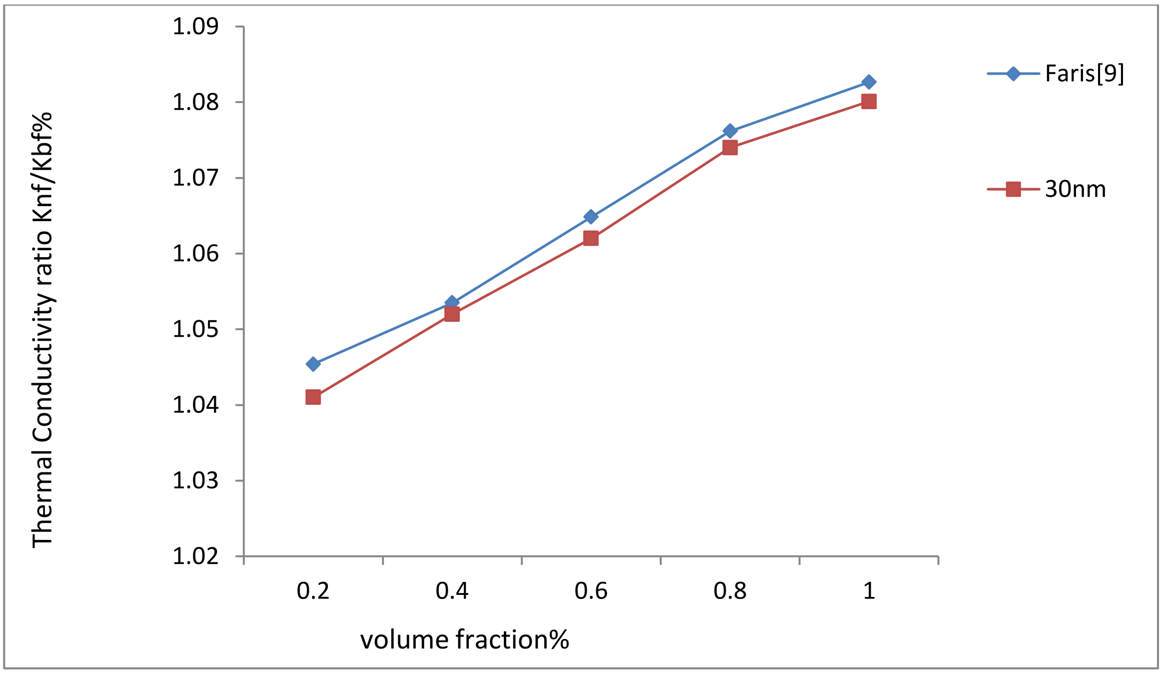

Figure 3: Depicting the enhancement in the heat conductivities of 30 nm Cr suspended in H_2O for range of volume fraction and compare with [ref.9]

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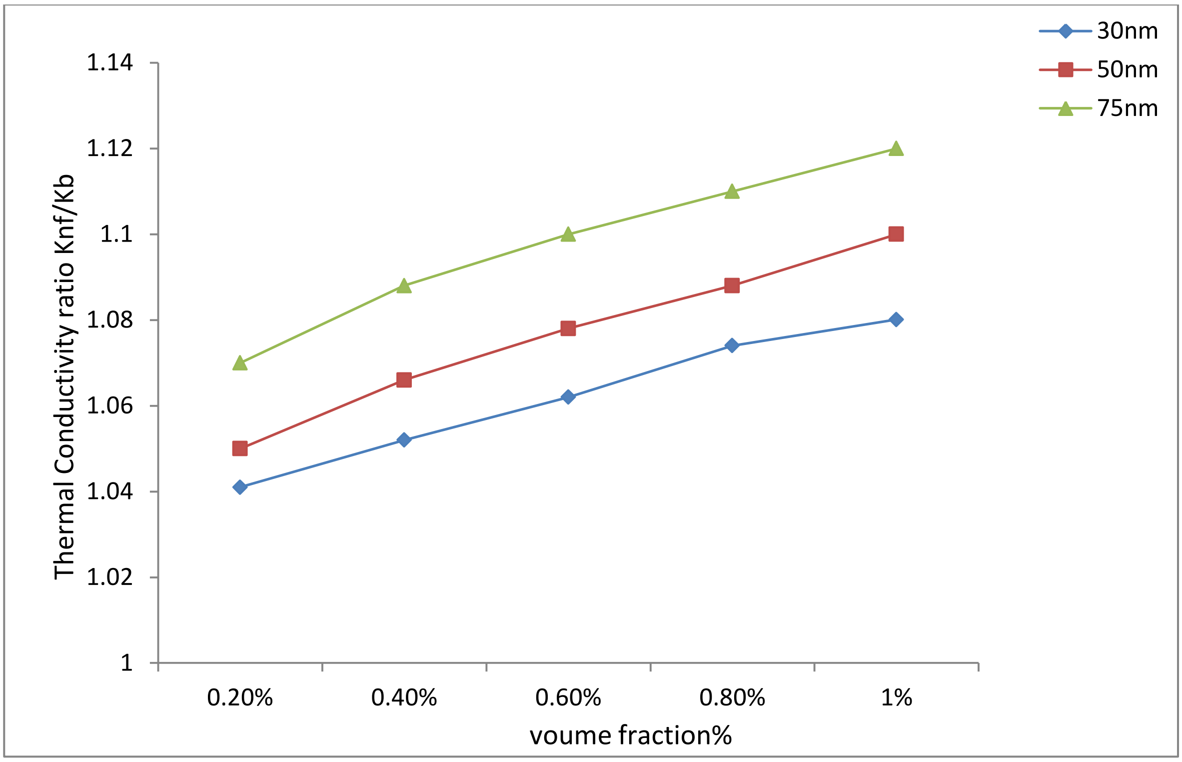

Figure 4: shows Thermal conductivity ratio of different size Cr nanoparticles with different size suspended in water for different volume fraction.

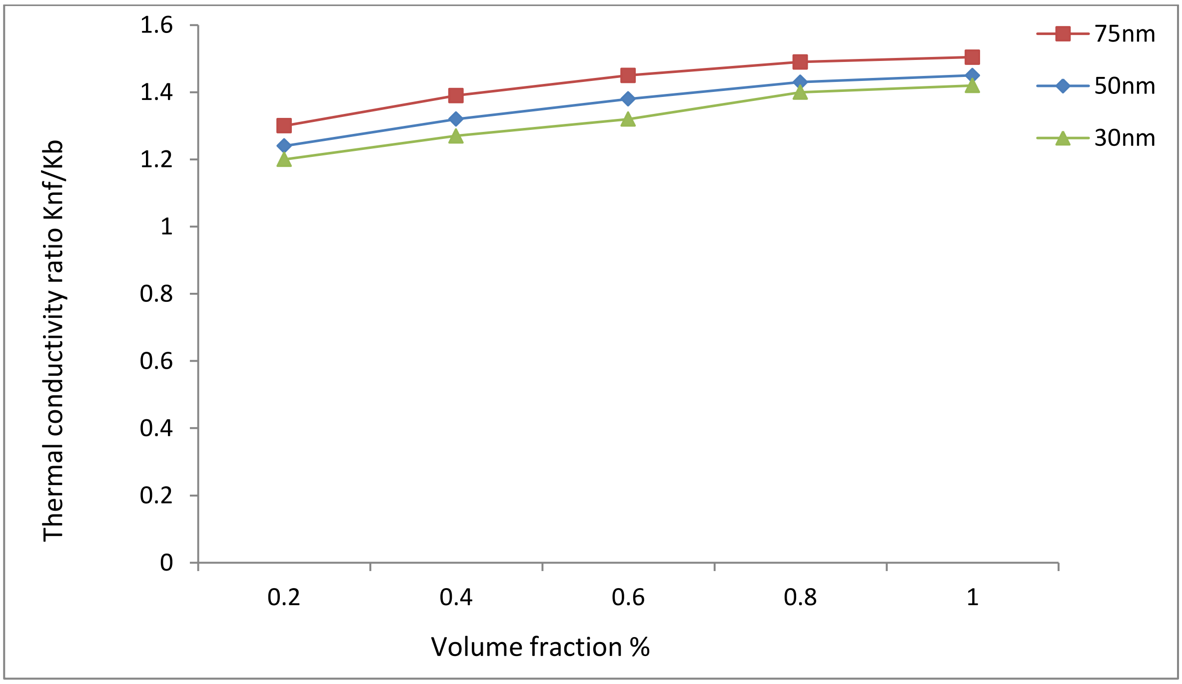

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Figure 5: Depicting heat conductivity ratio of different size Cr nanoparticles with different size suspended in ethylene glycol for different volume fraction.

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