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ORIGINAL RESEARCH PAPER

Experimental Investigation on Heat Transfer of Silver-Oil Nanofluid in Concentric Annular Tube

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Abstract

In order to examine the laminar convective heat transfer of nanofluid, experiments carried out using silver-oil nanofluid in a concentric annulus with outer constant heat flux as boundary condition. Silver-oil nanofluid prepared by Electrical Explosion of Wire technique and observed no nanoparticles agglomeration during nanofluid preparation process and carried out experiments. The average size of particles established to 20 nm. Nanofluids with various particle weight fractions of 0.12%wt., 0.36%wt. and 0.72%wt. were employed. The nanofluid flowing between the tubes is heated by an electrical heating coil wrapped around it. The effects of different parameters such as flow Reynolds number, diameter ratio and nanofluid particle concentration on heat transfer coefficient are studied. Results show that, heat transfer coefficient and Nusselt number increased by using naanofluid instead of pure oil. Maximum enhancement of heat transfer coefficient occurs in 0.72% wt. also results indicate that heat transfer coefficient increase slightly by using low wt. concentration of nanofluids.

1. Introduction

Miniaturization of heat transfer systems on the one hand and the large amount increase in heat transfer equipments on the other hand, necessitates the needs to increase heat transfer in a short time with a high rate. Many studies have been done to increase the heat transfer equipments which among them, increasing heated surfaces (fins), vibration of heated surfaces, injection or suction of fluid and etc can be noted [1-2]. This methods can barely afford heat transfer demands in process include electronic chips, laser systems and equipment with high energy. Therefore, there is an urgent need for new and innovative ideas to increase the heat transfer rate. Nanofluid technology offers high potential for the development of cooling systems with high performance, in small size and economical. Nanofluids are engineered by suspending nanoparticles with average sizes below 100 nm in

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	Nomenclature		
		q''	Heat flux(W/m^2)
		T	Temperature(^{0}C)
f	Darcy–Weisbach friction factor	Re	Reynolds Number
k	Thermal conductivity(W/m.^{0}C)	X	Distance from entrance of tube(m)
C_p	Specific heat(J/Kg.K)	ΔP	pressure drop along the test section(Pa)
D	Round tube diameter(m)		**Greek Symbols**
D_h	Concentric annular tube hydraulic diameter(m)	μ	Dynamic viscosity(pa.s)
h	Convective heat transfer coefficient (W/m^2.K)	ρ	Density(Kg/m^3)
$\bar{h}$	Mean Convective heat transfer coefficient(W/m^2.K)	ψ	Weight concentration
L	length of the tube (m)		**Subscripts**
p	Tube cross section perimeter(m)	Bf	Base fluid (base oil)
$\dot{m}$	Mole mass of the ith species (kg.mole^{-1})	i	Inlet
Nu	Nusselt Number	m	Mean fluid bulk temperature
Pr	Prandtl Number	nf	Nanofluid
Pe	Peclet Number	s	Surface

traditional heat transfer fluids such as water, oil, and ethylene glycol. A very small amount of guest nanoparticles, when dispersed uniformly and suspended stably in host fluids, can provide dramatic improvements in the thermal properties of host fluids.

Lee et al. [3] suspended CuO and Al_2O_3 nanoparticles with two different base fluids: water and ethylene glycol (EG) and obtained four combinations of nanofluids: CuO in water, CuO in EG, Al_2O_3 in water and Al_2O_3 in EG. Their experimental results showed that nanofluids have substantially higher thermal conductivities than the same liquids without nanoparticles. For example they reported that suspension of 4% volume fraction of 35 nm CuO particles in ethylene glycol shows 20% increase in thermal conductivity. Duangthongsuk and Wongwises, [4] investigated on comparison of the effects of measured and computed thermo physical properties of nanofluids on heat transfer performance. Their results showed that thermo physical properties predicted by theoretical models had almost the same accuracy as the experimental measured properties for the sake of Nusselt number calculation.

One of the other advantages of using nanofluid is higher heat transfer coefficient nanofluids in comparison to the base fluid. Xuan and Li [5] demonstrated the enhancement up to 35% for the turbulent forced convective heat transfer of Cu-H_2O nanofluid with nanoparticle concentration of 2.5 %vol. According to their report, the enhancement is lower for lower concentrations. Lai et al. [6] reported enhancement of Nusselt number about 8% for Al_2O_3-H_2O nanofluid with nanoparticle concentration of 1% vol. and size of 20 nm when the flow regime was laminar. Saha and Langille, [7] conducted experiments with water to study the effect of full length and short length strip inserts on heat transfer enhancements. They observed no significant decrease in heat transfer coefficient compared to full length tapes. However, the pressure drop is quite more. Yang et al., [8] did experiments with graphite-water nanofluids under laminar flow conditions. For a 2.5% wt. They experienced an increase in heat transfer of 22% over the base fluid at a temperature of 50 0C and 15% at a temperature of 70^{0}C. Kim et al., [9] used two different nanofluids in their experiments. They tested in the laminar and turbulent flow range. The two nanofluids they used were γ-Al_2O_3–water and amorphous carbonic water. In laminar flow the γ-Al_2O_3–water nanofluids had a heat transfer enhancement of around 14% whereas the amorphous carbonic nanofluid showed enhancement of around 7%. In turbulent flow, the γ -Al_2O_3–water nanofluids had an increase of around 20% and the amorphous carbonic water nanofluid showed no enhancement.

Mayer et al. [10] investigated the convective heat transfer and pressure drop of multi-walled carbon nanotubes flowing through a straight horizontal tube, all used nanofluids showed enhancement when comparing the data on a Re–Nu graph. When comparing the data with each other at the same fluid velocity, the nanofluids showed a decrease in heat transfer coefficient when compared with water. Numerical analysis of laminar flow heat transfer of

Al_2O_3- ethylene glycol and Al_2O_3-water nanofluids in tube has been reported by Palm et al., [11] and Roy et al., [12] and observed wall shear stress to increase with volume concentration and Reynolds number. Theoretical analysis for turbulent flow has been presented by Sarma et al., [13]. They compared the Nusselt number obtained from theory with their experimental data of Al_2O_3 nanofluid for 0.5% volume concentration. Recent developments in heat transfer enhancements with nanofluids are summarized in review articles by Kakaç and Pramuanjaroenkij, [14] and Wang and Majumdar [15]. Pooyan razi et al. [16] investigated Pressure drop and thermal characteristics of CuO–base oil nanofluid laminar flow in flattened tubes whit the heights of 11.5 mm (as round tube), 9.6mm, 8.3mm, 7.5mm and 6.3mm under constant heat flux. The results showed that the heat transfer performance is improved as the tube profile is flattened. Flattening the tube profile resulted in pressure drop increasing. Also they showed that, Nanofluids have better heat transfer characteristics when they flow in flattened tubes rather than in the round tube. Compared to pure oil flow, Maximum heat transfer enhancement of 16.8%, 20.5% and 26.4% is obtained for nanofluid flow with 2% wt. concentration inside the round tube and flattened tubes with internal heights of 8.3 mm and 6.3 mm, respectively. Because of the lack of experimental works on annular tubes and oil as base fluid in comparison with other reported studies in literates, this experimental study is done. In addition, since the stability of prepared nanofluids have undeniable and essential role in the results of experimental researches, the novel one step technique known as Electrical Explosion of Wire (E.E.W) is applied for preparation of utilized nanofluids. The aim of this study is empirical investigation of heat transfer in concentric annular tube at low volume concentration of silver-oil nanofluid in laminar flow at entrance region by Electrical Explosion of Wire (E.E.W).

2. Nanofluid preparation

There are two methods for nanofluids preparation:

one step method and two step method. Two steps method is dispersing the nanoparticles in base fluids after prepare the dry nanoparticles individually. In other hand, the one-step method is to disperse the nanoparticles in the base fluids at the same time with the synthesis of the nanoparticles. In Comparison with the two-step method, the one-step procedure has many benefits, such as less contamination of the particle, smaller particle size and high stability. Not only the one step method is expensive, but also the volume concentration of nanofluids is lower than the two step process. Moreover, almost all of the nanotechnology Companies, do not have a capacity to product nanofluids in large scale in quantities. Electrical Explosion Wire (E.E.W) as a one step method has so many differences relative to other one step procedures. In this Method by applying extra high electric voltage and current, the primary bulk wire is converted into the nanoparticles via pulse explosive process. It is worth to state that the whole process is one continuously and that is the main advantage of this technique. Among all physical methods developed for nanoparticle production, the Plasma technology is the most economic method. By this technique any wired conductive material can be transformed to the nanoparticles. Low cost, high efficiency and environmental friendly are other advantages of this technology. As mentioned before, the explosion of wire can be applied in gas or liquid media. Pure metal, oxides and also nitride can be obtained in electrical explosion of wire in gas media via controlling the chamber atmosphere. The ratio of the gas mixture in the chamber can be controlled by precise sensors and electronic controlling system. The underliquid explosion gives us the fully dispersed and stabilized metallic nanofluids in arbitrary liquid solution. In fact, the production, dispersion and stabilization is done simultaneously [17-18]. Figure 1 shows a schematic of E.E.W method.

As mentioned before, utilized Nanofluids, is made of E.E.W method. PNC1K device is an electrical explosion by placing electrodes in liquid media. Nanopowder production and distribution carried out simultaneously (Figure 2). It is necessary to mention that in this process, liquid phase consisting of deionized water (DW), oil, glycerin, alcohol, acetone, ethylene glycol, and hydrogen peroxide (H_2O_2) could be used. There is only one restriction on the use ofl iquid explosives and it is non-liquid electrolyte. It is necessary to explain that, another special feature of this system is the possibility of adding a surfactant to the liquid.

So, the nanofluid produced with this method, save primary distribution for a long time. Among all of the existing methods in the production of metal nanoparticles, electrical explosion method is the most economical and industrial method[19]. One of the greatest advantages of this method is the ability to produce metal and oxide nanopowders and metal oxide nanofluids of a wide range of metal nanoparticles.

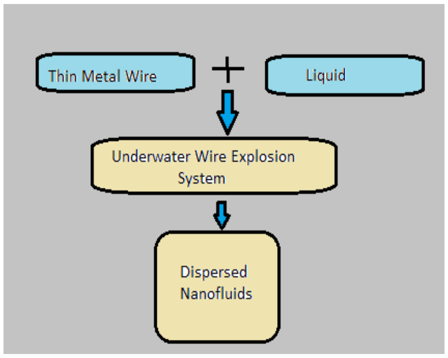

Fig. 1. schematic of E.E.W method

Fig. 2. PNC1Kdevice

In fact, any metal that can be made of thin wire, it will be possible to produce metal nanoparticles. For made applied Ag-oil nanofluid in this study, PNC1K device and thin wire were ready according to table 1.

Ag-H_2O, Ag-Glycerin, Ag-oil, Cu-H_2O, Cu-oil, Molybdene- H_2O, Au- H_2O, Brass- H_2O, Stainless Steel- H_2O, Nickel Curium- H_2O, Al- H_2O and Al- oil nanofluids could be obtained from PNC1K device more stabilized. From the Figure 3, it is crystal clear that the Ag nanoparticles are dispersed well and the mean diameter of the Ag nanoparticles is around 20 nm. Pure oil and Ag-oil nanofluid at 0.12% wt (0.022% vol.) prepared by E.E.W technique have shown in figure 4.

Table 1
characteristic operation of PNC1K for this study.

MODEL	PNC1k
Output voltage	0.5-1KV
Input power	1P 220VAC 500 W
Shot period	1-5 sec
Max. diameter wire	0.25mm
Exploding length wire	1-5 mm
Output wire	Ag
Particle size, average	15 nm

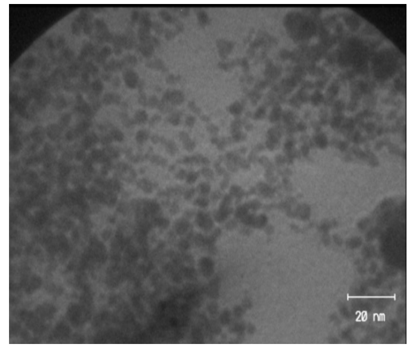

Fig. 3. TEM image of Ag nanoparticles

Fig. 4. Pure oil and Ag-oil nanofluid at 0.12% wt. prepared by E.E.W technique

3. Experimental apparatus

In order to examine convective heat transfer in the concentric annulus tube, the accurate experimental setup designed and assembled (Figure 5). the experimental setup chiefly includes a flow loop, a pump(CALPEDA, made in Italy, with three-speed motor) that it could provide easily demanded flows for perform the experiments, a nanofluid reservoir, a gate valve, a non return valve, test section, RTD PT100 temperature sensors, MPX-V5004DP pressure sensor, data analyzer USB 4716 and a three way valve. Test section has built of two copper tubes.

Inner tube has 1500mm length and its inner diameter is 6.35 mm or 12.7 mm and 1.0 mm thickness. Outer tube has 1500 mm length and 25.4 mm inner diameter and 1.3 mm thickness. An electrical wire coil wrapped around the outer copper tube, which links to AC power supply.

Then the outer copper tube was covered by the k-flux insulator. Two calibrated temperature RTD PT100 sensors are installed in entrance and exit the test section for measurement inlet temperature and outlet temperature of fluids. Nine RTD PT100 sensors were employed to measure the wall temperature of the test section and all of them welded optionally at 3, 7, 15, 25, 45, 100, 120, 130, 150 cm of axial distance. Every one of the PT100 sensors have been calibrated by portable programmable USB 4716 and their accuracy were found 0.1°C. Two PT100 sensors placed at opposite side of together on outlet of annulus for confidence of steady measured temperature. A 1 litter vessel and stopwatch accurate to 0.001s is used to measure the flow rate. Heat exchanger unit settle in after the test section. Fluid turn upside down to the pump from the fluid reservoir, then it pumps to the test section and bulk temperatures and wall temperatures measure with sensors. The experimental data for oil and nanofluids are listed in table 2.

4. Data collection and Data analysis

To calculate the convective heat transfer coefficient and other heat transfer properties, all of the rheological properties of both pure oil and nanofluid must be evaluated.

To determine the specific heat capacity (Cp) in different temperature of nanofluids and pure oil, a differential scanning calorimeter (DSC F3 Maia, manufactured by NETZSCH-Germany) was used. SVM3000 devise was used to calculate the density in different temperatures and weight fractions of nanofluid.

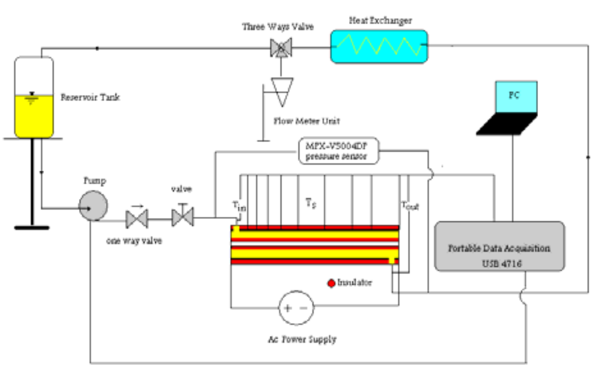

Fig. 5. Schematic of experimental setup

The thermal conductivity and viscosity of nanofluid and pure oil were measured by KD_2 thermal properties analyzer and Brookfield viscometer (DV-II + Pro Programmable Viscometer), respectively.

As figure 6 with consider the energy balance on a differential control volume of the fluid inside the tube:

$$\frac{dT_b}{dx} = \frac{q^{"}P}{\dot{m}C_p} = \frac{p}{\dot{m}c_p} h(T_s - T_b) \quad (1)$$

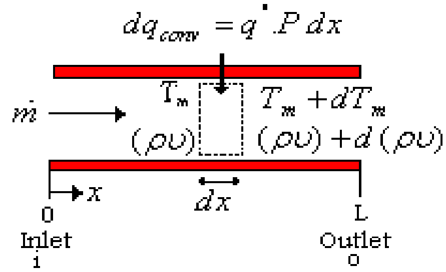

Fig. 6. energy balance on a differential control volume

Where $\dot{m}$ and P are mass flow rate and perimeter of the tube, respectively. T_s and T_b are the surface temperature and bulk temperature respectively. C_p is specific heat. Conservation of Momentum:

$$q^{"} = q_{conv}(P.L) \quad (2)$$

Also we have:

$$q_{conv} = \dot{m}C_p.(T_{mo} - T_{mi}) \quad (3)$$

So by integrate of x=0 and constant heat flux:

$$T_m(x) = T_{mi}(x) + \frac{q^{"}Px}{\dot{m}C_p} \quad (4)$$

X is the distance from tube inlet.
For calculate the convective heat transfer coefficient:

$$h(x) = \frac{q^{"}}{(T_s(x) - T_m(x))} \quad (5)$$

$$Nu(x) = \frac{h(x).D_h}{k} \quad (6)$$

Where D_h is hydrolic diameter and k is the thermal conductivity.all of the properties measured in average temperature as following:

$$T_m = (\frac{T_{b,in} + T_{b,o}}{2}) \quad (7)$$

$$D_h = D_o - D_i \quad (8)$$

Where, D_o and D_i are outer diameter and inner dia-

-meter respectively. Reynolds and Prandtl number are defined as follow:

$$\mathrm{Re} = \frac{4.\dot{m}}{\pi.D_h.\mu} \quad (9)$$

Also the mean heat transfer coefficient and mean Nusselt number are calculate as equation 11 and equation 12, respectively.

$$\mathrm{Pr} = \frac{\mu C_p}{k} \quad (10)$$

$$\bar{h} = \frac{1}{L}\int_0^L h(x)d(x) \quad (11)$$

Also the Nusselt Number calculated by equation 13:

$$N\bar{u} = \frac{\bar{h}.D_h}{k} \quad (12)$$

$$N\bar{u} = \sum_1^n \frac{Nu_n}{n} \quad (13)$$

5. Result and discution

5.1. Validation check

In order to verify the dependability and correctness of the experimental setup, Initial experiments are performed with oil as the working fluid. The experiments are conducted within the Reynolds number of 140.

Because of low Reynolds number and high Prandtl number of oil, hydrodynamically fully developed laminar flow and thermal entrance region for flow, are assumed respectively, for theoretical calculations (x/D< 0.05RePr).

The values of Nusselt numbers that are measured experimentally are compared with the values obtained by the following theoretical solution presented in equation 15. [20]

$$Pe = Re.Pr \quad (14)$$

$$Nu_x = \left[\frac{1}{Nu_\infty} - \frac{1}{2}\sum_{m=1}^{\infty}\frac{\exp(-\gamma_m^2 x^*)}{\gamma_m^4 A_m}\right]^{-1}.(\frac{\mu_s}{\mu_m})^{-0.14} \quad (15)$$

Table 3
The values of Am and γ2m [20].

m	A_m	γ^2_m
1	0.00763	25.68
2	0.002053	83.86
3	0.000903	174.2
4	0.000491	296.5
5	0.000307	450.9

In equation 15, Nu_∞ = 4.364 and Nu_x is the local Nusselt number at the distance of x from inlet of the test section, is a non-dimensional parameter, γ_m is the necessary eigenvalue and Am is a constant value. The values of Am and γ^2_m are displayed in table 3. For liquids, for instance oil, where viscosity variation is dependable for its rheological and thermal behavior, it is found that the correction coefficient, $(\mu_s/\mu_m)-0.14$, defined in equation 15 is often the best estimate. In this coefficient, μ_s is calculated at the surface temperature, while μ_m is evaluated at the bulk temperature. This solution is used for obtaining local Nusselt number of a fluid flow with temperature varying viscosity inside round tube under constant heat flux condition. Having the local Nusselt numbers at nine axial locations (3, 7, 15, 25, 45, 100, 120, 130, 150 cm of axial distance), the average Nusselt numbers are obtained using equations (11-13). Figure 7 shows the experimental results of mean Nusselt number for pure base oil in the circular tube at different Peclet number measured by equation 5 in comparison with those obtained by the theoretical equation 15. This figure indicates that Measurements agrees well with the predictions of this equation. Table 4 shows the values of experimental and theoretical data and relative errors between experimental and theoretical values.

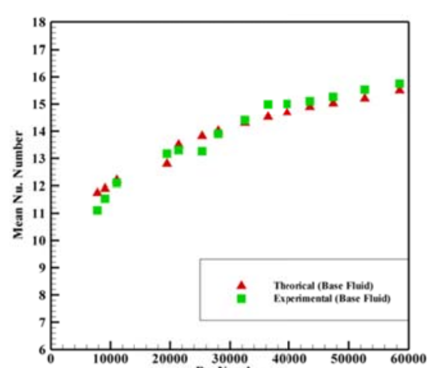

Fig. 7. comparison between experimental results and theoretical Equation [20] in straight tube

Table 4
the values of experimental and theoretical data and relative errors between experimental and theoretical values.

Mean Nu. Number (Experimental)	Mean Nu. Number (Theoretical)	error
11.1	11.74	5.76%
11.53	11.89	3.12%
12.1	12.2	0.83%
13.17	12.8	2.8%
13.3	13.5	1.5%
13.26	13.82	4.22%
13.9	14.01	0.79%
14.41	14.31	0.69%
14.98	14.53	3%
15	14.69	2.1%
15.1	14.89	1.3%
15.26	15.02	1.5%
15.53	15.2	2.1%
15.75	15.5	1.6%

By setting up an accurate and confident set up, the heat transfer characteristics of oil-based silver nanofluids flowing inside the concentric annular tubes are investigated experimentally for laminar flow conditions under constant heat flux. It is important to know that, obtained experimental data for heat transfer for each two specific cases of runs have not measured under exactly the same Reynolds numbers. This is because of the viscosity of oil-based nanofluid that is so dependent on fluid temperature and particle volume fraction.

5.2. Heat transfer characteristics

Variation of heat transfer coefficient related to silver-oil nanofluid as a function of Reynolds number for pure oil and the nanofluid with 0.12% (0.022% vol.), 0.36% (0.044% vol.) and 0.72% (0.176% vol.) weight concentration flow inside concentric annulus tube at constant heat fluxes of 204 watt shown in figure 8.

Based on the results, for certain Reynolds number, the convective heat transfer coefficient (h) of nanoparticles suspended in base oil is higher than base oil. This enhancement noticeably is reliant on the concentration of nanoparticles. For instance at Reynolds number about 73.45, the heat transfer coefficients are 7.33%, 13.7% and 17.32% greater than those of the base fluid when the nanoparticle concentration are 0.12%, .36.% and 0.72% wt., respectively. In point of fact, The nanofluid with suspended nanoparticles enhances the thermal conductivity of the mixture and a large energy exchange process resulting from the anarchic movement of nanoparticle decrease boundary layer thickness and delay in boundary layer development as claimed by previous research works [21-22].

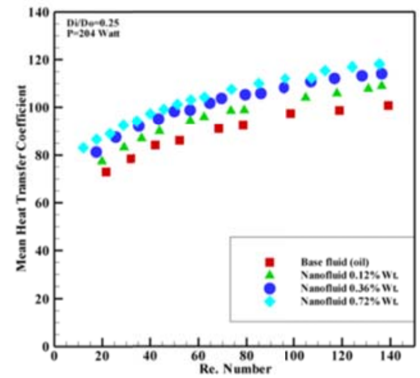

Fig. 8. variation of mean heat transfer coefficient versus Reynolds number at different weight concentration in concentric annular tube

It has seen that slightly enhancement in heat transfer coefficient with increasing nanoparticle concentration. A study on nanofluid's thermal conductivity organized by Buongiorno et al. [23] reveals that the nanofluid's thermal conductivity enhancement is noticeable only when the nanoparticle concentration is higher than 1 vol.%. Therefore, higher Nusselt number for nanofluid with low nanoparticle concentration is due to the heat transfer coefficient enhancement.

Figure 9 and figure 10 show the results for Ag-oil nanofluid with concentrations of 0.12%, 0.36% and 0.72% wt at various Peclet number at 204 watt on outer tube and laminar flow in concentric annulus tube. It shows the increments in Nusselt number and heat transfer coefficient by increasing the Peclet number.

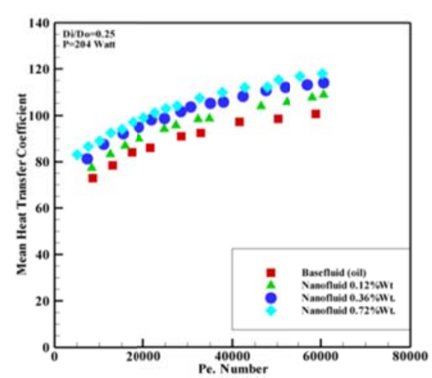

Fig. 9. variation of mean heat transfer coefficient versus Peclet number at different weight concentration in concentric annular tube

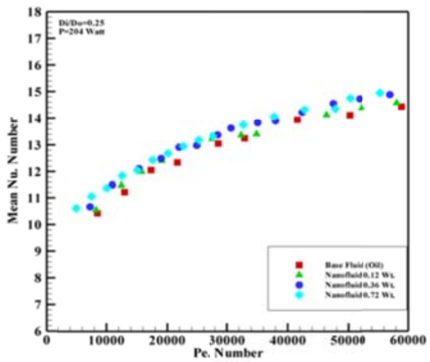

Fig. 10. variation of mean Nusselt versus Peclet number at different weight concentration in concentric annular tube

The enhancement of Nusselt number and heat transfer coefficient exhibit that the heat transfer performance of nanofluid is rely on various parameters such as Nanoparticles movement, Brownian motion and reduction in thermal boundary layer thickness and possible slip condition at the walls are other possible reasons for enhancement of heat transfer coefficient respectively, and the thermal conductivity is not the only main factor. Base on the results, at certain Peclet number, for example 41584, heat transfer coefficient with adding nanoparticles increase approximately 4.3%, 9.9% and 14.45% for weight concentration of 0.12%, 0.36% and 0.72% wt. respectively rather than using pure oil as base fluid.As shown in figure 11, that it shows the variation of heat transfer coefficient, changes with Reynolds number for different concentrations of Nanoparticles.

It is clear that by increasing the dimensionless diameter or reduce hydraulic diameter, heat transfer coefficient increases with increasing Reynolds number due to increasing the fluid velocity. More ever, by intensify the concentration of nanoparticles because of the increase of chaos and movement of nanoparticles, also improving the thermal conductivity, heat transfer coefficient of nanofluids increase than base fluid. With decrease the Hydraulic diameter, due to increase heat power per volume, bulk temperature increases and heat transfer coefficient increases.

As Shown in figure 12 in Reynolds number at 39.5, heat transfer coefficient for concentrations of 0.12%, 0.36%, and 0.72%, increase by 8%, 17.4%, 24.2% respectively compared to the base fluid. Due to the pressure drop for a concentric annulus tube with hydraulic diameter of 0.25 was large, the tests did not carried out for this hydraulic diameter.

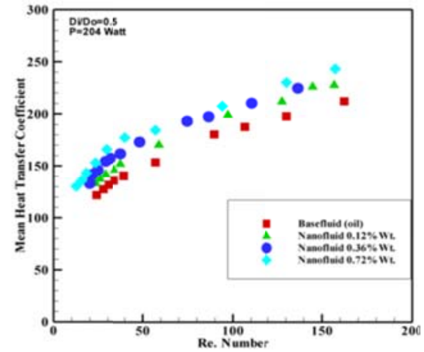

Fig. 11. variation of mean heat transfer coefficient versus Reynolds number at different weight concentration in concentric annular tube at Dh=0.0127 m

Figure 12 shows the ratio of convective heat transfer coefficient of Ag-oil nanofluid to the base fluid, versus Reynods number at concentrations of 0.12% , 0.36% and 0.72% wt. in concentric annulus tube with constant heat power of 204W in the laminar flow. Results indicated that the average heat transfer coefficient in concentrations of 0.12%, 0.36% and0.72% wt increase approximately 6.2%, 13.77% and 16.3% respectively, which causes it to increase the Brownian motion and movement of nanoparticles, also increase irregularity nanoparticles and reduce the thickness of the boundary layer.

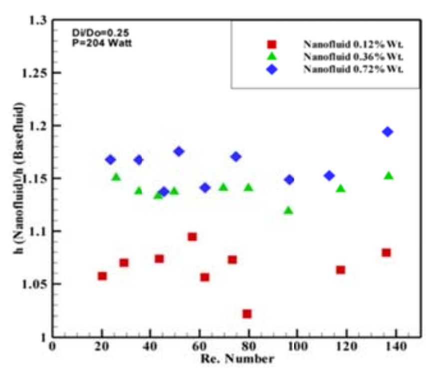

Fig. 12. ratio of convective heat transfer coefficient of nanofluid to the base fluid versus Re number

6. Conclusion

Convective heat transfer of Ag-oil nanofluid in laminar flow at low weight concentration (low volume concentration) inside a concentric annular tube investigated.

Results reveal that for nanofluid with 0.72% wt. maximum value of convective heat transfer coefficient of 16.6% compared to base oil occurred. Also the following results gained from this study:

1. Convective heat transfer coefficient increase in large scale, by increase the weight concentration at 0.12% wt. to 0.72% wt.

2. At the same flow condition with enhancing the diameter ratio (Di/Do), mean heat transfer coefficient increase noticeably.

Table2
Experimental data f or oil and nanofluids.

Run	φ (%)	h ($W/m^2.K$)	Nu	Re	Pr	Q (m^3/s)
1	0	72.88	10.44	21.62	394.64	0.00001
2	0	78.4	11.23	32.03	405.87	0.000015
3	0	84	12.04	42.13	411.48	0.00002
4	0	86	12.33	52.22	414.85	0.000025
5	0	91	13.04	68.4	418.1	0.000033
6	0	92.43	13.24	78.5	419.45	0.000038
7	0	97.3	13.94	98.7	421.32	0.000048
1	0.022	77.31	10.56	19.87	417.74	0.00001
2	0.022	83.24	11.48	29.08	428.05	0.000015
3	0.022	86.93	11.987	36.47	432.28	0.000019
4	0.022	89.98	12.4	43.86	435.07	0.000023
5	0.022	94.21	12.98	56.61	438.1	0.0000299
6	0.022	95.8	13.22	62.35	439.04	0.000033
7	0.022	98.48	13.36	73.45	440.45	0.000039
8	0.022	98.74	13.4	79	441.3	0.000042
1	0.044	81.3	10.68	17.49	417.95	0.00001
2	0.044	87.5	11.5	25.61	428.05	0.000015
3	0.044	92	12.1	35.37	433.79	0.000021
4	0.044	94.9	12.48	43.52	436.56	0.000026
5	0.044	98.1	12.9	50.03	438.17	0.00003
6	0.044	98.8	12.97	56.54	439.32	0.000034
7	0.044	101.7	13.37	64.69	440.45	0.000039
8	0.044	103.7	13.63	69.58	441.02	0.000042
9	0.044	105.2	13.83	79.35	441.93	0.000048
10	0.044	105.8	13.9	85.87	442.43	0.000052
1	0.176	83	10.62	12.06	417.7	0.00001
2	0.176	86.5	11.07	17.64	428.3	0.000016
3	0.176	89	11.38	23.25	433	0.00002
4	0.176	92	11.83	28.85	436.11	0.000025
5	0.176	94	12.03	34.46	438.12	0.00003
6	0.176	97	12.42	40.07	439.6	0.000035
7	0.176	99	12.67	45.68	440.65	0.00004
8	0.176	101	12.94	51.29	441.52	0.000045
9	0.176	103	13.17	56.9	442.2	0.00005
10	0.176	104.1	13.32	62.51	442.7	0.000055
11	0.176	107.5	13.75	73.73	443.6	0.000065

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