ARPN Journal of Engineering and Applied Sciences

ASSESSMENT OF THE COOLING PERFORMANCE OF AUTOMOBILE RADIATOR USING DIFFERENT HYBRID NANOFLUIDS

Khalid Faisal Sultan, Talib Z. Farge and Israa S. Ahmed
Department of Electro Mechanical Engineering, University of Technology, Baghdad, Iraq
E-Mail: 50084@uotechnology.edu.iq

ABSTRACT

In this article, the execution of constrained convection for two diverse half breed Nano liquids, viz., Cu (25nm) + Al (25nm) - refined water and Al_2O_3 (50nm)+ TiO_2 (50nm) - refined water tentatively considered at vehicle radiator. Four diverse concentrations of cross breed Nano liquid within the extent of 1 - 5 vol. % were arranged by the augmentations half breed nanoparticles into the refined water as base liquid. The stream rate of coolant is changed within the run of 20 l/min - 70 l/min. Crossover Nano coolants display colossal alter within the warm exchange compared with the refined water. The warm exchange execution of Cu + Al - refined water cross breed Nano liquid was found to be way better than Al_2O_3 + TiO_2- refined water half breed Nano coolant. Besides, the Nusselt number is found to extend with the increment within the half breed nanoparticle concentration and half breed Nano liquid speed. The sort and estimate of cross breed nanoparticle play a critical part in advancement of warm exchange rate. The rate of warm exchange is expanded with increase in concentration of half breed nanoparticles for the primary sort around 35 % warm exchange change was accomplished with expansion of 5 vol % crossover nanoparticles. Besides the moment sort of cross breed nanoparticles expanded up 23 % with expansion of 5 % vol concentration.

Keywords: hybridnanofluid, automobile radiator, performance.

1. INTRODUCTION

The enhancement of warm trade frameworks execution will be diminished the vitality Utilization and presented upgrade strategies for warm exchange [1 - 3]. Examined the improvement of warm exchange with variety the geometric of warm exchanged by utilizing diverse sorts of balances within different embedded pipe and type of exterior unpleasantness. [4 - 5] had examined purpose of attractive area, electric and pulse strategies for warm exchange upgrade of the warm exchanged [6]. Exploratory examined heat transport of warm exchanged for Nano fluids with in Nano particles littler of 100 nanometer and laminate stream. We have gotten the next warm accessibility than fluid wanting a Nano particle [7]. Improvements warm accessibility by utilizing Nano liquids for particle of cupric oxide to get greats warm characteristic [8]. Examined tentatively advantages of oxide nanoparticles aluminum oxide together with H_2O standard on disorder transport warm exchange [9 - 10]. Inspected test the enhancement the warm trade by utilizing Nano fluid of nanoparticles of Aluminum oxide together with H_2O standard and various situation. Comes almost appears up that degree of warm trade for Nano fluid extended while atom of Nano fluid particle concentricity raise as well Reynolds figure raise [11 - 13]. Explored improvements for heat transport warm exchange for Nanofluid with a Nanoparticle of Titanium Dioxide - refined H_2O. They had gotten for higher degree of warm exchange for Nano fluid than the standard liquid.

For this study degree of warm exchange for constrained heat transport for two sorts of Nano liquid (copper, aluminum + Distilled water) are consider tentatively. Moreover impact for channel temperature from half breed Nano liquid and volume division of nanoparticle on the improvement the warm exchange are examined.

2. EXPERIMENTAL WORK

Hybrid Nanoparticles:

The first type of hybrid nanoparticles cupper Cu (25nm) + Aluminum Al (25nm) and the second type of hybrid nanoparticles Aluminum oxide Al_2O_3 (50nm) + titanium oxide TiO_2 (50nm).

3. PREPARATION OF THE HYBRID NANOFLUID AS COOLANT

The arrangements of hybrid Nano liquid tests are arranged by scattering pre - weighed amounts of dry particles of copper and Aluminum in refined water. The blends were at that point undergo to Ultrasonic blending [150 kHz, 500 Watt at 25- 30 ° centigrade, and Toshiba, Britain] for time (2 h) for separate any molecule totals. Half breed Nano fluid for substance where contain refined H_2O with half breed Nano particles from (US Investigate Nano materials, Inc). The pictures of planning to crossover Nano fluids are appeared in Figure-1.

Figure-1. Hybrid Nano fluid cupper Cu (25nm) + Aluminum Al (25nm) and Aluminum oxide Al_2O_3 (50nm) + titanium oxide TiO_2 (50nm).

4. EXPERIMENTAL METHODS

The device utilized within the tests comprises of the taking after and appeared in Figure-2,

a) Pump gives a changing stream average of 20-70 litter /minute.

b) Storage tank pipes,

c) An electrical radiator utilized to warming the working liquid and controllers were utilized to preserve the temperature between 40 and 80 ^{0}C.

d) Flow meter sort Dwyer arrangement MMA smaller than expected - Ace stream meter utilized to degree mass stream rate straightforwardly with the exactness of 0.4 l/min.

e) Forced draft fan (Techno pars 1500 rpm).

f) Globe valve utilized to direct the stream rate in rig.

g) Thermocouples ((T - sort)

h) Utilized at gulf and outlet of the radiator as well as eight thermocouples (T - sorts). These thermocouples were settled at put along the area of test and introduced within the surfaces of radiator at a center.

i) Radiator (a cross stream warm exchanger) as appeared in Figure-3. The speed and discuss temperature is steady within the tests due to clearly investigate the inner warm exchange. The characteristics of the radiators tabulated in Table-1.

Table-1. Radiator determinations are tabulated.

Kind of fin and pipe	Aluminum
Distance of Radiator	320*20*382.4 m meter
Finform	Corrugated
Heat transfer area	1.25Square meter
Part size	4.7Square meter
Size of fin	1.14 liter

Figure-2. Experimental setup.

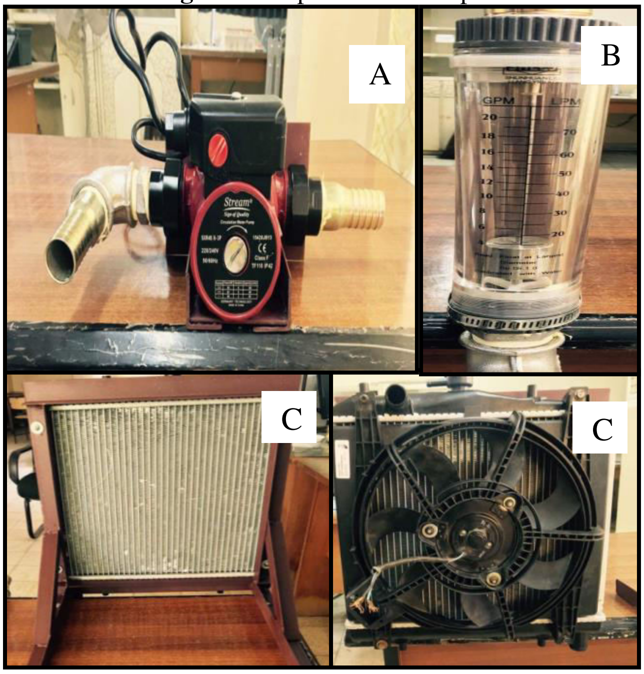

Figure-3. Appear pump (A) Stream meter (B) Warm exchanger (radiator) (C).

5. DATA PREPARING OF HYBRID NANO FLUID

The thermo physical characteristics for crossover Nano liquid was studied at normal size temperature of crossover Nano liquid by taking after conditions.

Density [14].

$$\rho_{hb,nf} = \Phi_{np1}\,\rho_{np1} + \Phi_{np2}\,\rho_{np2} + (1 - \Phi_{np1} - \Phi_{np2})\rho_{DW} \quad (1)$$

Viscosity [14].

$$\mu_{hb,nf} = [1 + 2.5(\Phi_{np1} + \Phi_{np2})]\mu_{Dw} \quad (2)$$

Specific heat [14].

$$\rho_{hb,nf}Cp_{hb,nf} = \Phi_{np1}\,\rho_{np1}Cp_{np1} + \Phi_{np2}\,\rho_{np2}Cp_{np2} + (1 - \Phi_{np1} - \Phi_{np2})\rho_{DW}Cp_{DW} \quad (3)$$

ARPN Journal of Engineering and Applied Sciences

Recently Huang *et al.* [15] played an successful warm conductivity demonstrate (Eq.4)

$$\frac{k_{nb,nf}}{k_{Dw}} = \left[\frac{Cp_{hb,nf}}{Cp_{Dw}}\right]^{-0.023} \left[\frac{\rho_{hb,nf}}{\rho_{DW}}\right]^{1.358} \left[\frac{\mu_{hb,nf}}{\mu_{Dw}}\right]^{0.126} \quad (4)$$

The taking after strategy to get warm exchange coefficient and comparing Nusselt number has been done. Agreeing to Newton's law of cooling:

$$Q = hADT = hA(T_b - Tw) \quad (5)$$

Warm exchange rate can be calculated as takes after:

$$Q = m\,Cp\,\Delta T = m\,Cp\,(Tin, hb, nf - Tout, hb, nf) \quad (6)$$

With respect to the uniformity of Q in the above equations:

$$Nu_{hb,nf} = \frac{h_{ex} D_h}{k_{hb,nf}} = \frac{\dot{m}\,Cp(Tin,hb,nf - Tout,hb,nf)\,D_h}{k_{hb,nf}} \quad (7)$$

Improvement of warm exchange amidst situation of crossover Nano liquid and standard liquid situation is characterized as:

$$Enhancement = \frac{Nu_{hb,nf} - Nu_{bf}}{Nu_{hb,nf}} x\,100 \quad (8)$$

6. RESULTS AND DISCUSSIONS

In arrange to confirm the exactness and the unwavering quality of the test framework, the warm exchange coefficients are tentatively measured utilizing base refined water as the working liquid some time recently getting those of Cu (25nm) + Al (25nm) - refined water cross breed Nano liquids. Compare where made amidst the comes about of the exploratory and three famous experimental relationships: one of it proposed by Dittuse Boelter relationship [16], Gnielinsky relationship [17] and lasts created by Petukhov *et al.* [18] (Figure-5). The three relationships were appeared in conditions (9-13), separately. In conditions (11 - 13), f is abrasion agent.

$$Nu = 0.0235\,Re^{0.8} Pr^{0.3} \quad (9)$$

$$Nu = \frac{\left(\frac{f}{2}\right)(Re - 1000)\,Pr}{1 + 12.7\left(\frac{f}{2}\right)^{0.5}\left(Pr^{\frac{2}{3}} - 1\right)} \quad (10)$$

$$f = (1.58\ln(Re) - 3.82)^{-2} \quad (11)$$

$$Nu = \frac{\left(\frac{f}{8}\right)\,Re\;Pr}{1.07 + 12.7\left(\frac{f}{8}\right)^{0.5}\left(Pr^{\frac{2}{3}} - 1\right)} \quad (12)$$

$$f = (1.82\log(Re) - 1.64)^{-2} \quad (13)$$

From figure-4 impartially perfect approval can show amidst Gnielinsky equation and measurements through Reynolds number extend applied for this work.

Figuress (5-6) appear dimensionless thermal characteristic of two hybrid Nano fluids Copper (25nm) + Aluminum (25nm)- Distilled waterand Al_2O_3 (50nm)+ TiO_2 (50nm) - distilled water with rapprochement with those of distilled water. Figures shown the thickness, warm accessibility and consistency expanded with expanding concentricity of crossover Nano particles whereas particular warm diminished with expanding concentration of the half breed Nano particles. Warm accessibility for half breed Nano liquids Cu (25nm) + Al (25nm) - refined water was more noteworthy than crossover Nano liquids Al2O3 (50nm)+ TiO2 (50nm) - refined water due to half breed nanoparticles estimate and warm conductivity for the copper and aluminum. Figuress (7 - 12) appear the impact of the Reynolds number, hybrid nanoparticle volume division and half breed Nano liquid channel temperature on Nusselt number for the two sorts of the half breed Nano liquids Cu (25nm) + Al (25nm) - refined water and Al_2O_3 (50nm)+ TiO_2 (50nm) - refined water. The speed components of crossover Nano liquid increment as a result of an increment of vitality transport within the half breed Nano liquid within expanding volume division. Affectability for warm limit coat thickness to volume division for crossover Nano particles is linked to expanded warm accessibility of the crossover Nano liquid. Reality, higher amount for warm accessibility went with by higher amount of thermal diffusivity. Higher esteem for thermal diffusivity reason of decline within temperature angles and in like manner increments the limit coat thickness [19]. Increment for warm limit coat thickness diminishes the Nusselt number, while, the Nusselt number could be a increase of temperature angle and the warm accessibility characteristic (conductivity of half breed Nano fluid to accessibility of the refined water). Since diminishment in temperature angle because of nearness for cross breed Nano particles was highly littler than warm accessibility proportion, in this manner, an improvement in Nusselt number is taken put by expanding the volume division of hybrid Nano particles. Subsequently, expansion of cross breed Nano particles to the coolant has the potential to move forward car and overwhelming - obligation motor cool average, or similarly causes to expel motor warm with a diminished - measure cooled framework. In arrange to treat impact of temperature on warm execution of the radiator, diverse liquid gulf temperatures have been connected for all concentricity. Crossover Nano liquid gulf temperatures incorporate (50, 60 and 75 °centigrade) for the two kind crossover Nano liquids Cu (25nm) + Al (25nm) - refined water and Al2O3 (50nm)+ TiO2 (50nm)– refined water. These figures shown that an increment within the cross breed Nano liquid gulf temperature marginally improves Nusselt number because of enlargement within the impact of test fluid radiation to the inner divider of the tubes. Moreover, these figures appear that Nusselt number increments with the increment of Reynolds number. The impact of the Reynolds number, hybrid nanoparticles volume division and cross breed Nano liquid gulf temperature on upgrade in warm exchange are appears in Figures (13-18). The upgrade in warm exchange has expanded by expansion within the concentrations of half breed nanoparticle, Reynolds number and crossover Nano fluid channel temperature. For the refined water based hybrid Nano fluid it is clear that the upgrade increments with Reynolds number and at higher concentrations of half breed nanoparticle the impact of Reynolds number gets to be articulated. Advancement within the warm exchange average for distinctive concentricity for two sorts of hybrid Nano fluid can tabulated in Table-2.Increase in warm exchange of hybrid Nano fluid Cu (25nm) + Al (25nm) - refined water was more noteworthy than hybrid Nano fluid Al_2O_3 (50nm) + TiO_2 (50nm)- refined water due to cross breed nanoparticles estimate and warm conductivity of the copper and aluminum.

Table-2. The two types of the hybrid Nano fluids advancement.

T (°C)	**Φ (vol%)**	**Enhancement (%) Hybrid Nano fluid Cu (25nm) + Al (25nm) – distilled**	**Enhancement (%) Hybrid Nano fluid Al_2O_3 (50nm)+ TiO_2 (50nm)– distilled water**
50	1	5.4	3.45
	3	7.33	4.27
	5	9.25	6.10
60	1	6.89	4.09
	3	8.45	6.76
	5	10.67	8.12
75	1	7.28	5.24
	3	13.45	8.33
	5	17.33	11.52

7. CONCLUSIONS

The summary results from used two types of hybrid Nano fluids are as follows:

a. Enhancement of warm exchange and coolant of car radiators based on sort of cross breed Nano fluids

b. The upgrade in warm exchange for the half breed Nano fluid Cu (25nm) + Al (25nm) - refined water was more noteworthy than crossover Nano fluid Al_2O_3 (50nm) + TiO_2 (50nm)– refined water due to half breed nanoparticles estimate and warm conductivity of the copper and aluminum.

c. The fuel utilization will diminish and advanced the car motor execution due to utilized half breed

b) Nano fluid as working liquid as comes about leads to change warm transfer.

a. Nusselt number expanded with the expanding of crossover Nano fluid channel temperature, half breed nanoparticle volume division and Reynolds number.

b. Thermal conductivity for the crossover Nano fluids Cu (25nm) + Al (25nm) - refined water was more noteworthy than crossover Nano fluids Al_2O_3 (50nm)+ TiO_2 (50nm) - refined water due to crossover nanoparticles estimate and warm conductivity for the copper and aluminum.

REFERENCES

[1] L.D. Tijing, B.C. Pak, B.J. Baek, D.H. Lee. 2006. A study on heat transfer enhancement using straight and twisted internal fin inserts, International Communications in Heat and Mass Transfer. 33(6): 719-726.

[2] P. Naphon. 2006. Effect of coil-wire insert on heat transfer enhancement and pressure drop of the horizontal concentric tubes. International Communications in Heat and Mass Transfer. 33(6): 753-763.

[3] B. Sahin, A. Demir. 2008. Performance analysis of a heat exchanger having perforated square fins. Applied Thermal Engineering. 28(5e6): 621-632.

[4] Z. Zhnegguo, X. Tao, F. Xiaoming. 2004. Experimental study on heat transfer enhancement of a helically baffled heat exchanger combined with three dimensional finned tubes. Applied Thermal Engineering. 24(14e15): 2293-2300.

[5] M.Y. Wen, C.Y. Ho. 2009. Heat-transfer enhancement in fin - and - tube heat exchanger with improved fin design, Applied Thermal Engineering. 29(5-6): 1050-1057.

[6] S.H. Hashemabadi, S. Gh. Etemad. 2006. Effect of rounded corners on the secondary flow of viscoelastic fluids through non - circular ducts, International Journal of Heat and Mass Transfer. 49: 1986-1990.

[7] S.H. Hashemabadi, S.Gh. Etemad, M.R. Golkar Naranji, J. Thibault. 2003. Laminar flow of non-Newtonian fluid in right triangular ducts, International Communications in Heat and Mass Transfer. 30(1): 53-60.

[8] Yakut B. Sahin. 2004. Flow-induced vibration analysis of conical rings used for heat transfer enhancement in heat exchangers, Applied Energy. 78(3): 273-288.

[9] S. Laohalertdecha, S. Wongwises. 2006. Effects of EHD on heat transfer enhancement and pressure drop during two-phase condensation of pure R - 134a at high mass flux in a horizontal micro - fin tube, Experimental Thermal and Fluid Science. 30(7): 675686.

[10] .S. Paschkewitz, D.M. Pratt. 2000. The influence of fluid properties on electro hydrodynamic heat transfer enhancement in liquids under viscous and electrically dominated flow conditions. Experimental Thermal and Fluid Science. 21(4): 187-197.

[11] N. Umeda, M. Takahashi. 2000. Numerical analysis for heat transfer enhancement of a lithium flow under a transverse magnetic field. Fusion Engineering and Design. 51-52, 899-907.

[12] D. Wen, Y. Ding. 2004. Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions. International Journal of Heat and Mass Transfer. 47,5181-5188.

[13] M.S. Liu, M.C.C. Lin, I.T. Huang, C.C. Wang. 2006. Enhancement of thermal conductivity with CuO for nanofluids, Chemical Engineering and Technology. 29(1): 72-77.

[14] Jahar Sarkar, Pradyumna Ghosh, Arjumand Adil. 2015.A review on hybrid nano fluids: Recent research, development and applications, Ho CJ, Huang JB, Tsai PS, Yang YM. Preparation and properties of hybrid water based suspension of Renewable and Sustainable Energy Reviews. 43: 164-177.

[15] F.W. Dittus, L.M.K. Boelter. 1930. Heat Transfer in Automobile Radiators of Tubular Type. University of California Press, Berkeley, CA. pp. 13-18.

[16] V. Gnielinsky. 2002. Wärmeübertragung in Rohren, VDI-Wämeatlas, sixth ed. VDI Verlag, Düsseldorf.

[17] Petukhov B. 1970. Heat transfer and friction in turbulent pipe flow with variable physical properties. Advances in heat transfer. 6: 503-564.

[18] E N. Ashwin Kumar, Norasikin Binti Mat Isa, R. Kandasamy. 2015. Impact of Heat Transfer on MHD Boundary Layer of Copper Nanofluid at a Stagnation Point Flow Past a Porous Stretching and Shrinking Surface with Variable Stream Conditions. ARPN Journal of Science and Technology. 5(5).

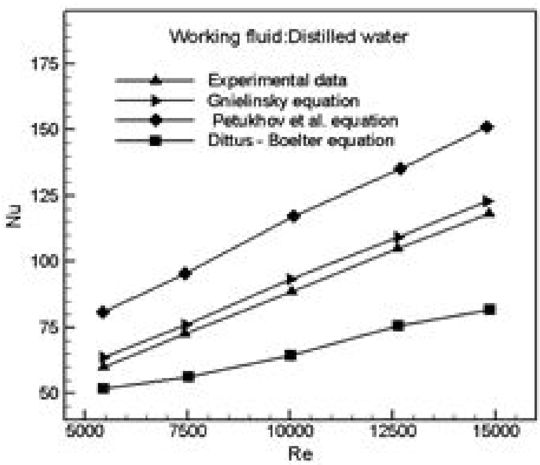

Figure-4. Test comes about for refined water in compare with comes about gotten in past work.

VOL. 15, NO. 12, JUNE 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

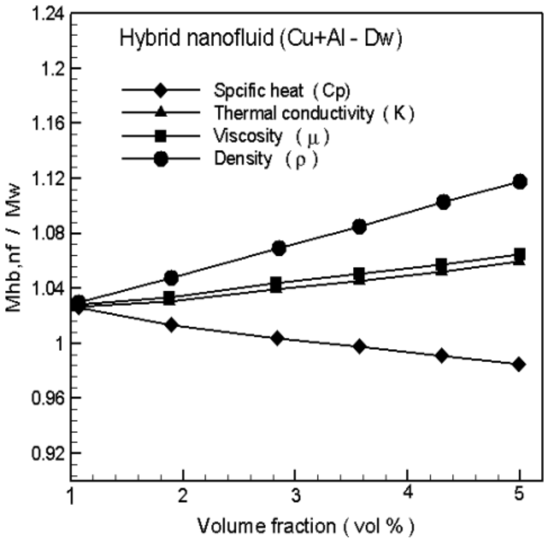

Figure-5. Dimensionless warm characteristic of cross breed(Cu+ Al – Dw) in comparewith those of distilled water.

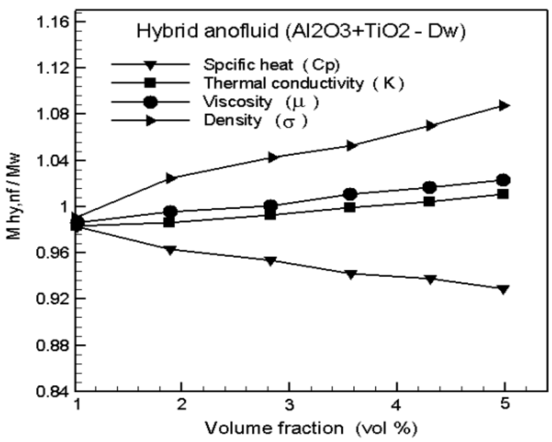

Figure-6. Dimensionless warm characteristic ofcross breed(Al_2O_3+TiO_2 – Dw) in compare with those of distilled water.

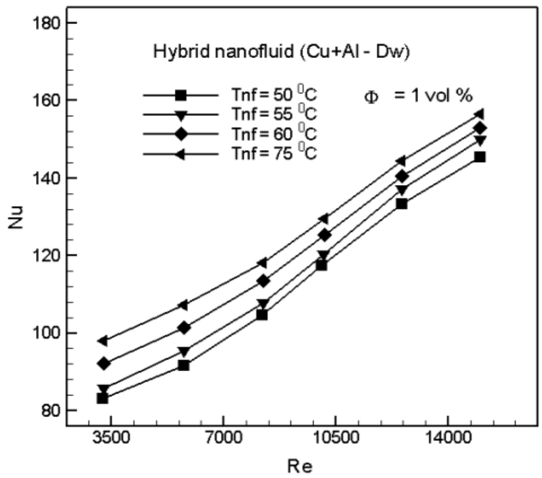

Figure-7. Variety of Nu number with Reynolds number inlettemperature at Φ=1 vol% for (Cu +Al – DW).

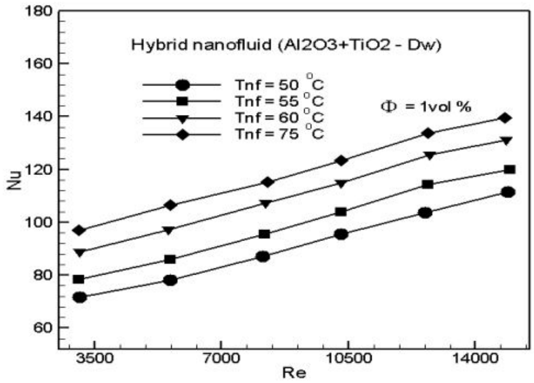

Figure-8. Variety of Nu number with Re number inle temperature at Φ=1 vol %for (Al_2O_3 +TiO_2– DW).

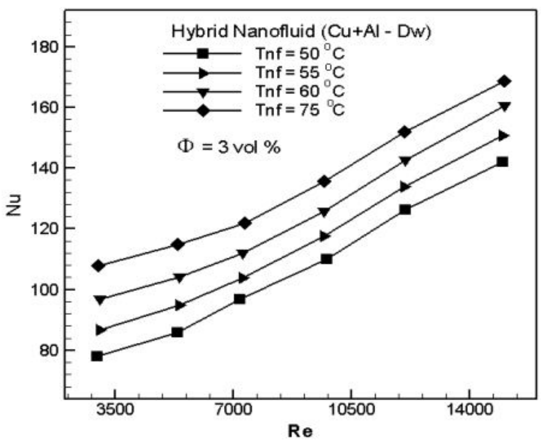

Figure-9. Variety of Nu number with Reynolds number inlettemperature at Φ=3 vol% for (Cu +Al – DW).

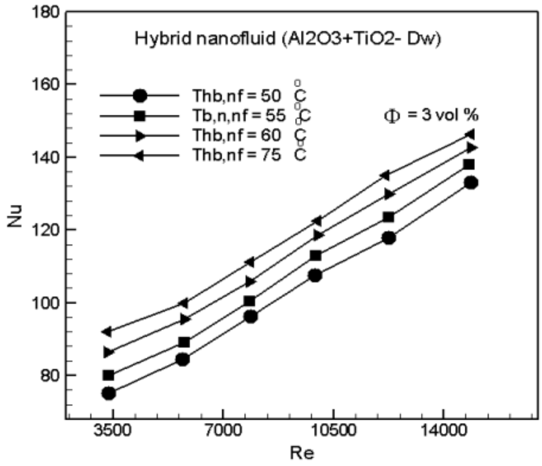

Figure-10. Variety of Nu number with Re number inlet temperature at Φ=3 vol % for (Al_2O_3 +TiO_2– DW.

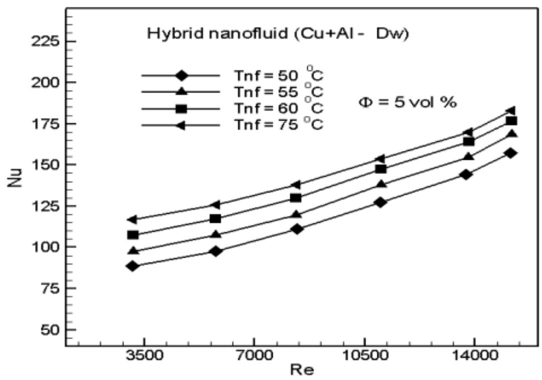

Figure-11. Variety of Nu number with Reynolds number inlet temperature at Φ=5 vol% for (Cu +Al – DW).

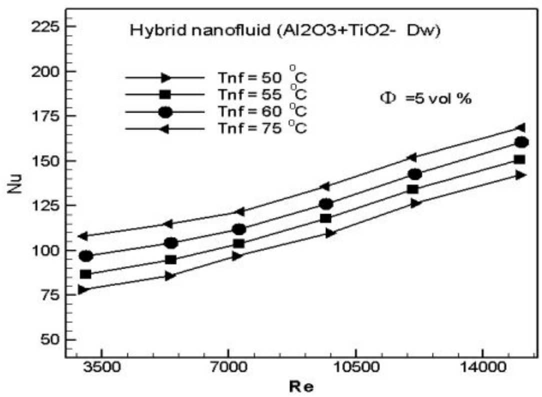

Figure-12. Variety of Nu number with Re number inlet temperature at Φ=5 vol % for (Al_2O_3 +TiO_2– DW).

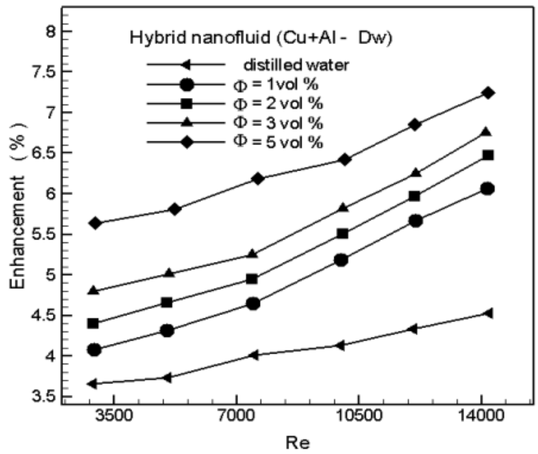

Figure-13. Variety of Enhancement with Re ,Φ and Thb,nf = 50 ^{O}C for (Cu +Al – DW).

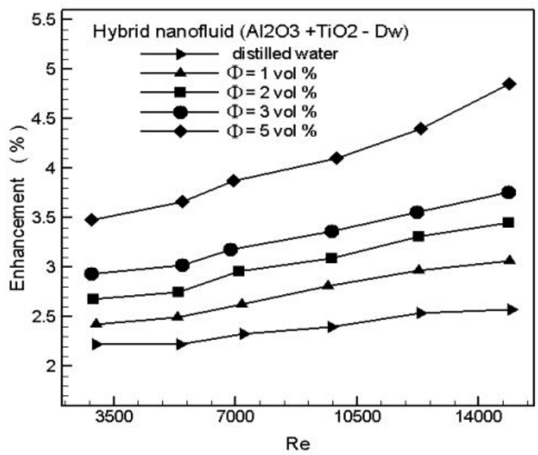

Figure-14. Variety of Enhancement with Re , Φ and Thb,nf = 50 ^{O}C for (Al_2O_3 +TiO_2 – DW).

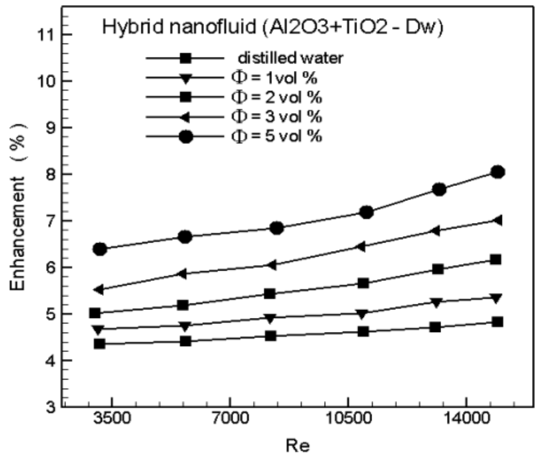

Figure-15. Variety of Enhancement with Re, Φ

VOL. 15, NO. 12, JUNE 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

and Thb,nf = 60 ^{O}C for (Cu +Al – DW).

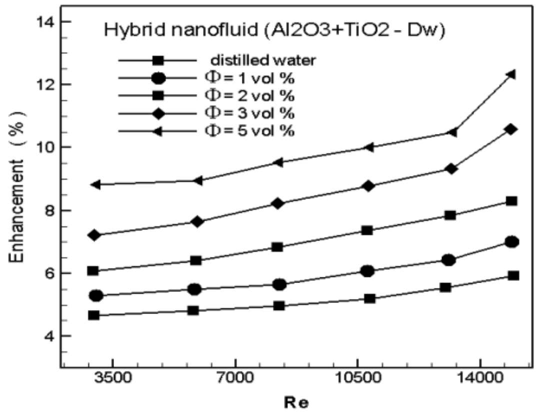

Figure-16. Variety of Enhancement with Re , Φ and Thb,nf = 60 ^{O}C for (Al_2O_3 +TiO_2 - DW).

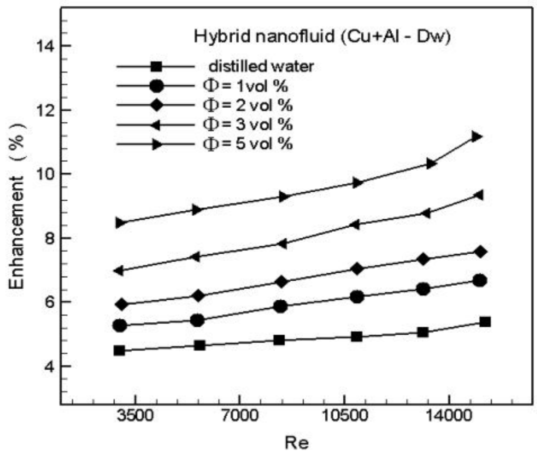

Figure-17. Variety of Enhancement with Re , Φ and Thb, nf = 75 ^{O}C for (Cu +Al - DW).

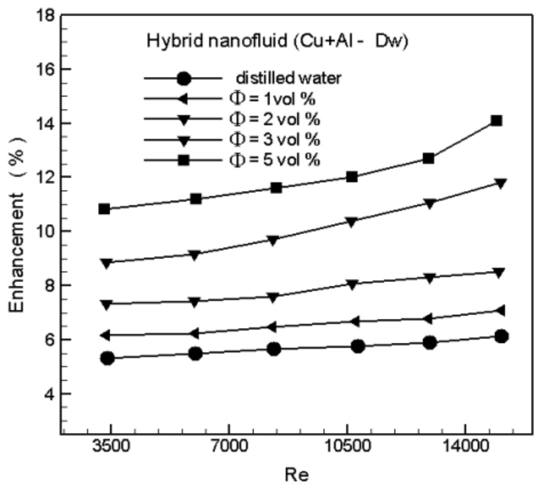

Figure-18. Variety of Enhancement with Re, Φ and Thb, nf = 75 ^{O}C for (Al_2O_3 +TiO_2 – DW).

Nomenclature

Symbol	Quantity	units
A	peripheral area	m^2
Q	thermal energy	J
Cp	Specific heat	J/kg k
d_{hy}	hydraulic diameter $=\frac{4A}{P}$	m
h	heat transfer coefficient	W/m^2 K
$\dot{m}$	Mass flow rate	kg/s
Nu	Nusselt number	__
Pr	Prandtl number $= \frac{\mu}{\rho\ \alpha}$	—
Re	Reynolds number $= \frac{4\dot{m}}{\pi\ dhy\ \mu}$	—
T	Temperature	°C
f	Friction factor	m
Dw	Distilled water	
	Greek Symbol	
μ	Dynamic viscosity	$N.s/m^2$
ρ	density	Kg/m^3

Φ	Volume concentration	__
	Subscripts	
bf	Base fluid	__
hb,nf	Hybrid nanofluid	__
in	input	__
out	output	__
w	wall	__