iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: VII Month of publication: July 2018

DOI: http://doi.org/10.22214/ijraset.2018.7016

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

Performance Analysis of Shell and Tube Heat Exchanger by using AL_2O_3 & CuO Nanofluid

Atul A Raut[1], Prof. Katwate R.R[2]
[1]Depattment of Mechanical Engineering, University of Pune

Abstract: The efficiency of the heat exchanger depends directly on the heat transfer coefficient of the material. However, to improve the thermal performance of the system, a lot more is required from the aspect of the heat transfer fluid. Maximum improvements in cooling capabilities have been constrained because of less thermal conductivities of the working fluids, which is vital in the enhancement of heat transfer. By using nano-sized (1–100 nm) solid particles as an additive suspended in the base fluid is one of the technique to enhancement heat transfer. This study aims to evaluate the performance of the heat transfer characteristics of water based nanofluid as a working fluid for heat exchanger. For the based fluid, a mixture of water & Nanoparticles Al2O3 and CuO Nano particles of concentration 0.1% to 0.5% were added to the base fluid and then evaluate the heat transfer characteristics of the nanofluid. The mass flow rate of nanofluid in the shell and tube was kept at different flow rate between 2 to 9 LPM. The performance of the heat transfer characteristics were evaluated based on certain parameters which are the heat transfer coefficient, thermal conductivity, Absorption rate, effectiveness, Renaults Number, friction factor, Nusselt number, and rate of heat transfer of the Nanofluids. It was found that the nanofluid that exhibited the highest heat transfer performance was the Al2O3 with 0.2% volume fraction in water.
Keywords: heat exchanger, Al_2O_3 and CuO Nano particles, thermal conductivity, heat transfer coefficient, Absorption rate, effectiveness, friction factor, Nusselt number

I. INTRODUCTION

Traditional heat transfer fluids such as Water, Ethylene Glycol and engine oil are used as coolants in many industrial applications and in process industries, such as transport vehicles, engine cooling, condensers and electronic devices. These types of fluids have poor thermal conductivities. This can be overcome by dispersing the micro particles which are having higher thermal conductivity. But, the dispersion of micro particles possesses some problems. The micro particles suspended because some problems in heat transfer equipment. The term Nanofluid means the stable colloidal suspension of nano-sized solid particles in the common base fluids such as ethylene glycol and water.

Nanofluids are prepared by adding nanoparticles into traditional heat transfer fluids are the next generation heat transfer fluids as they offers the exciting new possibilities to increase the heat transfer performance as compared to traditional fluids. Therefore, nanofluids have drawn a great attention due to their hidden benefits for some applications such as HVAC, process industry, thermal power plant, energy supply microelectronics and transportation. The surface area of nanoparticles is nearly 1000 times higher than that of the micro particles. The larger surface area of the nanoparticles increases the heat conduction in nanofluids, since heat transfer takes place on the surface of the particles. Nanoparticles are very small in size so they reduce erosion, clogging, decreases pumping power; reduce supply of the heat transfer fluid, and significantly save energy.

II. PROBLEM STATEMENT

Previous research on nanoparticles for Heat Exchanger has been conducted in order to increase heat exchange performance in shell and tube so that more heat will be absorbed. In current practice, there are two types of nanoparticles have to be investigate for performance analysis :

Mix nanoparticles with fluid medium in heat exchanger and checking feasibility of its use in shell and tube heat exchanger

III.EXPERIMENTATION

The objective of the present work is to enhance the performance of shell and tube heat exchanger using Al2O3/water and CuO/water nanoparticle. The nanofluid is prepared by using two step method in which selected amount of particle are mixed with water and stirred it up to 5-6 hours, so that particle get mix with water. The nanofluid is then passing through shell side and hot water through tube. the temperature is recorded by placing thermocouple at hot and cold inlet-outlet.

The temperatures are measured at four different points by RTD type thermocouples.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

Cold fluid (nanofluid) inlet temperature=T1=T_{nfi}
Cold fluid (nanofluid) outlet temperature=T2=T_{nfo}
Hot water inlet temperature=T3=T_w
Hot water outlet temperature=T4=T_w

Table I.
Physical Properties of Nanoparticle

Nano particle	Mean Dia	Density (Kg/m^3)	Thermal conductivity (W/mK)	Specific heat (KJ/Kg K)
Al2O3	80nm	3925	43	780
CuO	40nm	3720	20	580

Table II.
Technical Specifications of Experimental Setup

Sr. No.	Description	Shell	Tube
1	Material	Mild Steel	Mild Steel
2	Outer Diameter (mm)	160	25
3	Inner Diameter (mm)	150	20
4	Thickness (mm)	5	2.5
5	Test length(mm)	700	650
6	Quantity	1	5

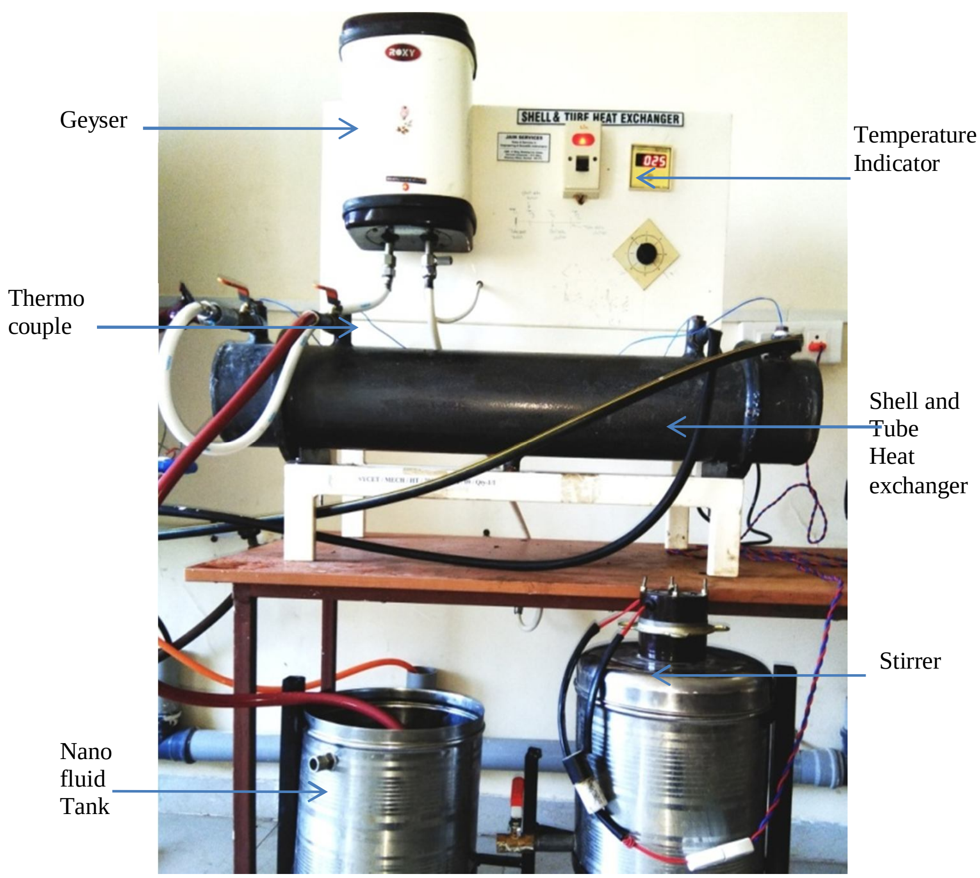

Fig. 1: Experimental Setup

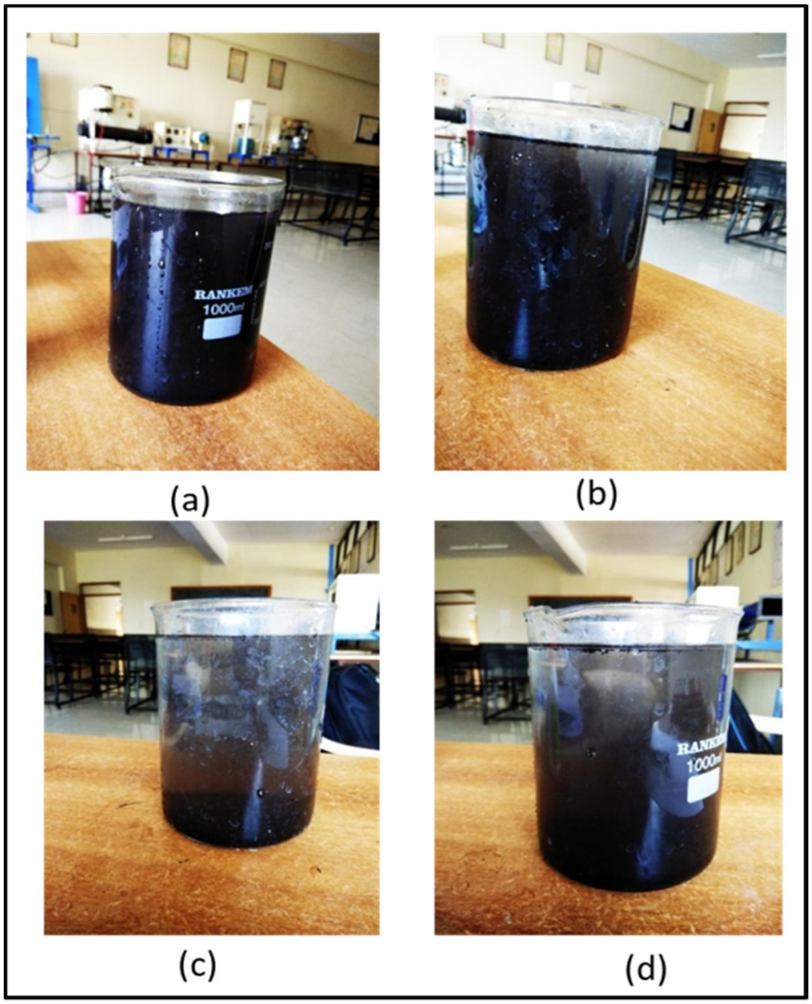

Fig. 2 Preparation of Nano Fluid

A. Calculation of Thermal conductivity of nanofluid for different volume fraction.

Maxwell model [21] is used to determine the thermal conductivity Of Nano fluids as follows

$$Knf = \frac{Kp + 2Kw + 2(Kp - Kw)\phi}{Kp + 2Kw - (Kp - Kw)\phi} \times Kw$$

Kw = Thermal conductivity of water, Kp = Thermal conductivity of nanoparticle

Φ = the particle volume fraction of the suspension.

For 0.1 % volume fraction

$$K_{nf} = \frac{43 + 2 * 0.613 + 2(43 - 0.613).001}{43 + 2 * 0.613 - (43 - 0.613)0.001} * 0.613$$

$$Knf = \frac{44.52}{44.20} * 0.613$$

$$Knf = 0.6168$$

B. Calculating Density of nanofluid for different mass fraction.

Pak and Cho equation [22] is used to evaluate the density of nanofluid as follows:

$$\rho_{nf} = \emptyset\rho p(1 - \emptyset)\rho w$$

Density for 0.1% volume fraction of Al2O3

$$\rho_{nf}\, for\ 0.1\% = (0.1/100)3925(1 - 0.1/100)998$$

=3909.31

C. Calculating Specific heat of nanofluid for different mass fraction.

To determine the specific heat capacity of nanofluid, Xuan and Roetzel equation [23] is used

$$Cp(nf)=(1-\emptyset)Cp_w+\emptyset Cp_{(p)}$$

For 0.1% volume fraction

$$Cp(nf) \text{ for } 0.1\%=(1-0.1/100)*4187+(0.1/100)*740$$

$$=4184$$

Table III
Thermal Conductivity of Al_2o_3 /Water Nanofluid

Concentration	K_w	K_p	K_{nf}
0.1%	0.613	43	0.636
0.2%	0.613	43	0.648

Table IV.
Density of Al_2o_3 /Water Nanofluid

Concentration	ρ_w	ρ_p	ρ_{nf}
0.1%	998	3925	1006
0.2%	998	3925	1008
0.3%	998	3925	1009

Table V.
Specific Heat of Al2o3 /Water Nanofluid

Concentration	Cpw	Cp(p)	Cp(nf)
0.1%	4187	580	4183
0.2%	4187	580	4180
0.3	4187	580	4175

IV. RESULT AND DISCUSSION

The various experimental results such as Nusselt number, Overall heat transfer coefficient, effectiveness are obtained for pure water, $Al_2O_{3,}$/water and CuO/water nano fluid.

A. Analysis of performance parameters

$$LMTD = \frac{(Thi-Tci)-(Tho-Tco)}{Log[\frac{Thi-Tci}{Tho-Tco}]} \quad (1)$$

Heat carried by cold fluid $=m_{nf}Cp_{nf}(\Delta T)$ (2)

Heat carried by Hot fluid =m Cp(ΔT) (3)

Overall heat transfer coefficient $Ui = \frac{Q}{Ai\ \Delta T}$ (4)

Renoults number $Re = \frac{\rho v di}{\mu}$ (5)

Velocity of fluid $V = \frac{m}{\rho Ac}$ (6)

Pradit Number $Pr = \frac{Cp\ \mu}{K}$ (7)

Nusselt Number can be find out by using relation proposed by Dittus and Boelter [22].

$Nu = 0.023Re^{0.8}Pr^{0.3}$ (8)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

$$h = \frac{Nu\,K}{d} \quad (9)$$

$$\text{Effectiveness} = \frac{Qactual}{Qmaximum} \quad (10)$$

$$\text{Effectiveness}(\varepsilon) = \frac{mh\,Cph\,(Thi-Tho)}{(mcCp)s(Thi-Tci)} \quad (11)$$

B. Discusion on Different Parameters

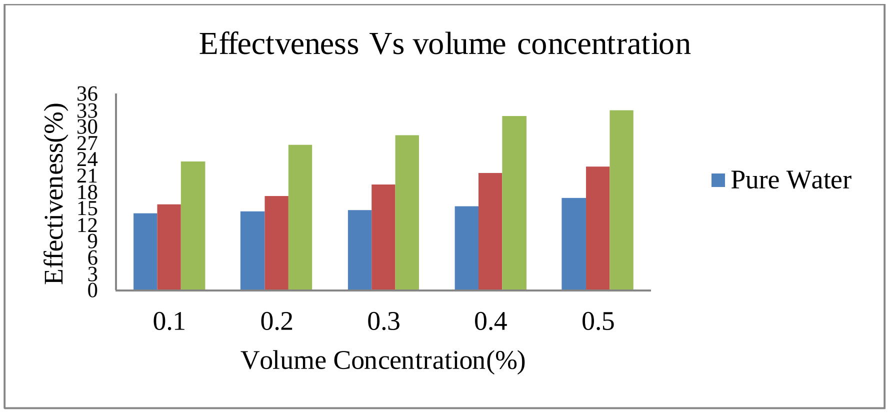

Fig.4 Effectiveness vs particle volume fraction of Nano fluid.

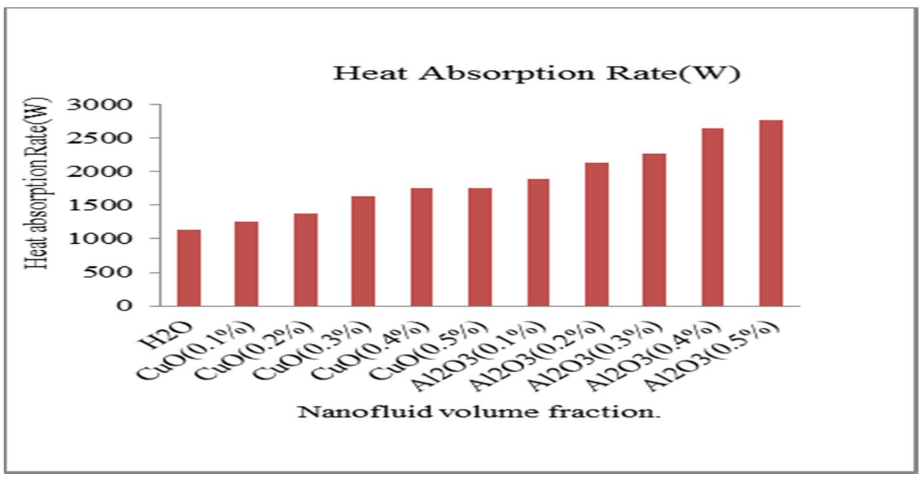

Fig.5 Absorption Rate vs. particle volume fraction of Nano fluid.

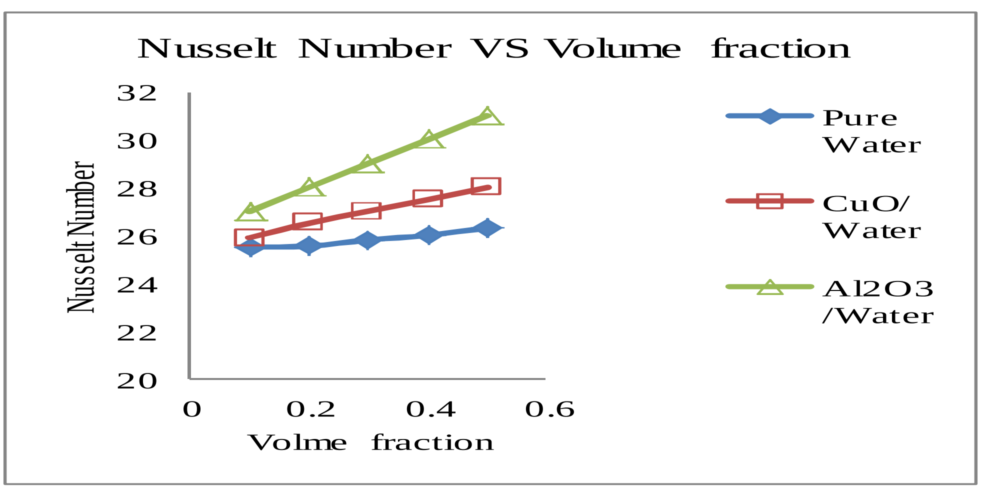

Fig.6 Nusselt Number VS Volume fraction

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

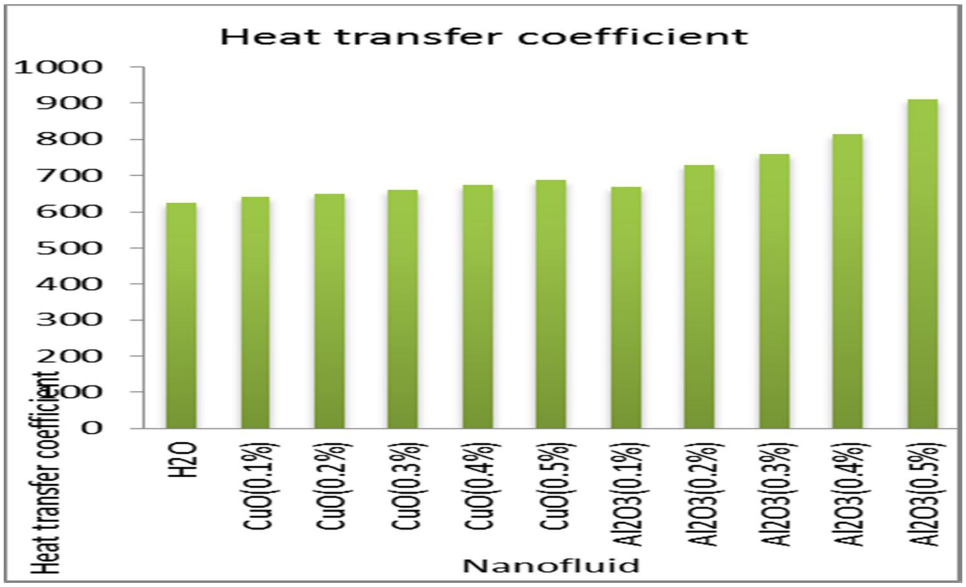

Fig.7 Heat transfer coefficient vs. particle volume fraction of nanofluid.

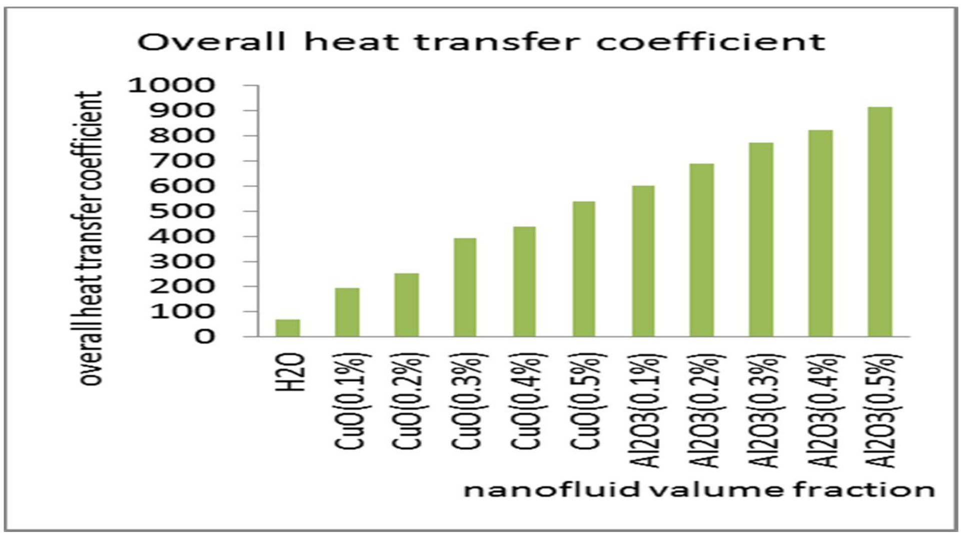

Fig.8 Heat transfer coefficient vs. particle volume fraction of Nano fluid

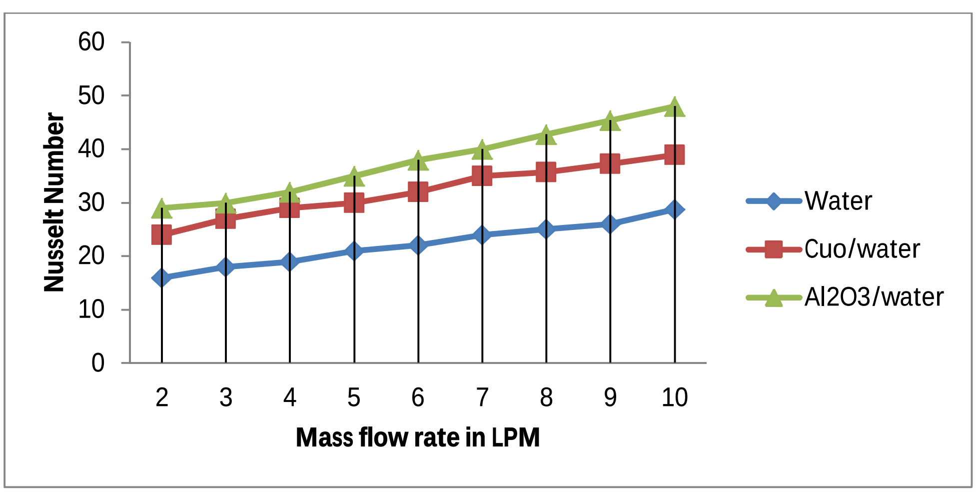

Fig.9 Nusselt number vs. Mass flow rate.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

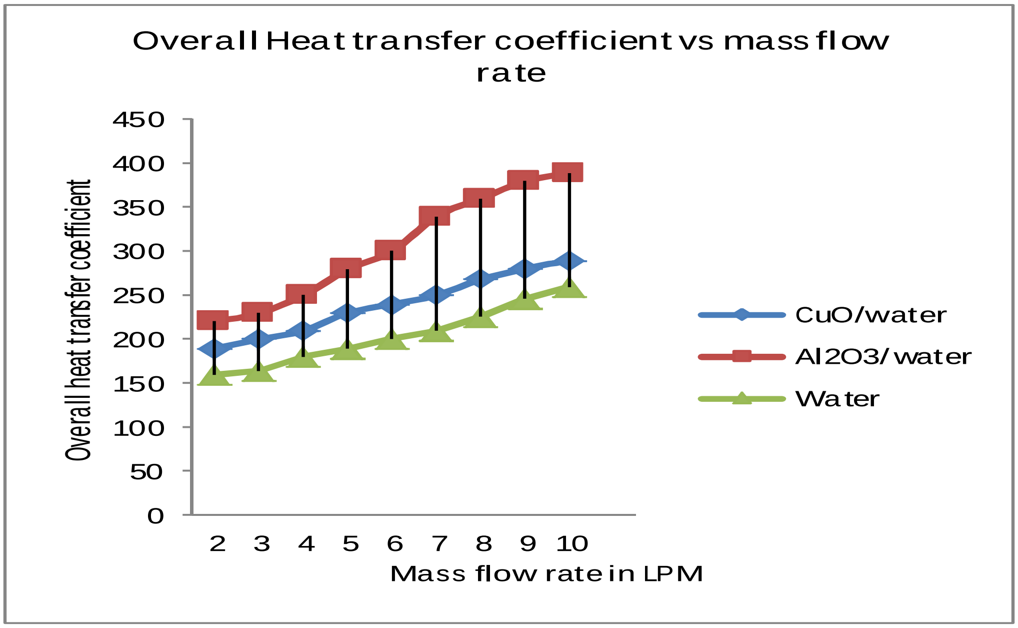

Fig.10.Overall heat transfer coefficient vs Mass flow rate.

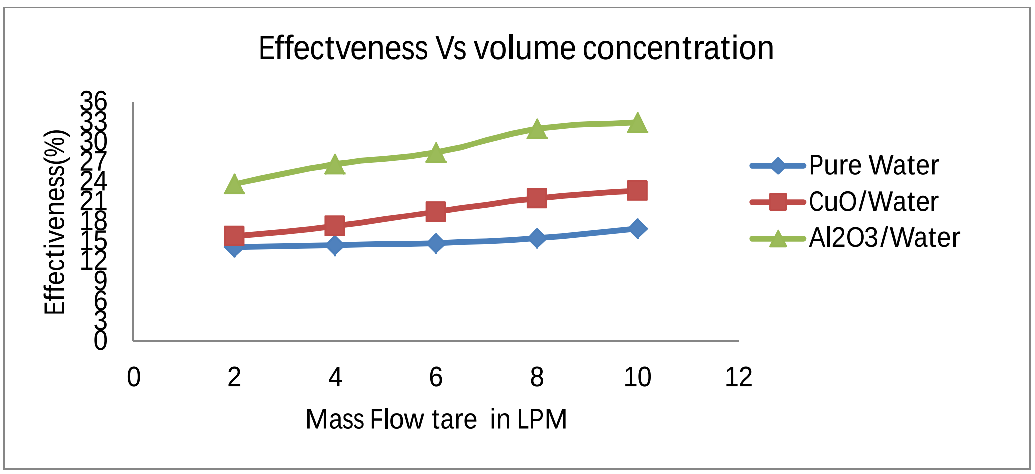

Fig.11 Effectiveness vs. Mass flow rate.

V. CONCLUSIONS

Experimental study has been conducted on water and 0.1 to 0.5 % volume fraction of Al_2O_3/water nanofluids and CuO/ water Nanofluid flowing through a pipe of shell and tube heat exchanger. In this study, the effect of nanoparticle concentration of Al_2O_3/water, and CuO/water and flow rate on the heat transfer coefficient of water and nanofluids was examined. The experiments were performed at different flow rates between 2 to 9 LPM and different volume concentration ranging 0.1% to 0.5% each of Al_2O_3/water, and CuO/water eac. The thermo-physical properties of nano fluids e.g. thermal conductivity, viscosity & density were measured by using numerical correlations. Pressure drop, friction factor, Reynolds number and Nusselt number were calculated. The following conclusions were drawn from the experimental study:

A. The thermal conductivity of 0.2 % alumina/water nanofluids increases with increase in temperature. At a fixed temperature, the thermal conductivity of alumina/water nanofluids is higher than that of distilled water because nanoparticles have much higher thermal conductivity as compared to Water.
B. Viscosity and density of 0.2 volume % alumina/water nanofluids decrease with increase in temperature because the intermolecular forces weaken when heated up. At any fixed value of temperature, nanofluids have higher values of density and viscosity than that of water.

C. As the flow rate increases from 2 LPM to 9 LPM, the heat transfer coefficient of water as well as of nanofluids increases. At a fixed flow rate of 3 LPM nanofluids have much higher heat transfer coefficient than that of water.

D. By using 0.2 % of Al_2O_3 /Water maximum enhancement of 22 % in heat transfer coefficient was observed at a 3 LPM flow rate compared to water. With using 0.2 % of CuO/Water maximum enhancement of 19 % in heat in heat transfer coefficient was observed at 3 LPM flow rate compared to water.

E. The results show that the heat transfer coefficient enhancement was increases with increase in volune concentration of nanofluid in water.

F. With using Nanofluid the nussult number enhances significantly than pure water as cold fluid.

G. At same particle concentration and flow rate the Al2O3/water nanofluid gives higher effectiveness than that of CuO/water and pure water as cold fluid.

H. From the above results obtained, it was concluded that the Overall performance of shell and tube heat exchanger depends on nanomaterial and particle concentration of nanofluid.

REFERENCES

[1] C. Selvam1, D. Mohan Lal1, and Sivasankaran Harish Thermophysical properties of ethylene glycol-water mixture containing the silver Nanoparticles Journal of Mechanical Science and Technology 30 (3) (2016) 1271~1279

[2] P.J. Fule, B.A. Bhanvase , S.H. Sonawane Experimental investigation of heat transfer enhancement in helical coilheat exchangers using water based CuOnanofluid Advanced Powder Technology xxx (2017) xxx–xxx

[3] Vikas Kumar, Arun Kumar Tiwari, Subrata Kumar Ghosh Effect of chevron angle on heat transfer performance in plate heatexchanger using ZnO/water nanofluid Energy Conversion and Management 118 (2016) 142–154

[4] Rahim Hassanzadeha, ArifOzbekband Mehmet Bilgilib Analysis of Alumina/Water Nanofluid in Thermally DevelopingRegion of a Circular Tube Thermal Engineering, 2016, Vol. 63, No. 12, pp. 876–886

[5] Rashmi R. Sahoo1 JaharSarkar, Heat transfer performance characteristics of hybrid nanofluidsas coolant in louvered fin automotive radiator Heat Mass Transfer (2017) 53:1923–1931

[6] Lu Zheng a, YonghuiXiea,DI Zhang, Numerical investigation on heat transfer performance and flow characteristics in circular tubes with dimpled twisted tapes using Al2O3-water nanofluid International Journal of Heat and Mass Transfer 111 (2017) 962–981

[7] Ningbo Zhao a, Jialong Yang a, Hui Li b, Ziyin Zhang a, Shuying Li Numerical investigations of laminar heat transfer and flow performance of Al2O3–water nanofluids in a flat tube International Journal of Heat and Mass Transfer 92 (2016) 268–282

[8] P. C. Mukesh Kumar, J. Kumar and S. Suresh Experimental investigation on convective heat transfer and friction factor in a helically coiled tube with Al2O3 / water nanofluid†Journal of Mechanical Science and Technology 27 (1) (2013) 239-245

[9] M.M. Sarafraz, F. Hormozi, V. NikkhahThermal performance of a counter-current double pipe heat exchanger working with COOH-CNT/water nanofluidsExperimental Thermal and Fluid Science 78 (2016) 41–49

[10] S.M. Peyghambarzadeh S.H. Hashemabadi, M. Seifi Jamnani, S.M. Hoseini Improving the cooling performance of automobile radiator with Al2O3/waterNanofluid Applied Thermal Engineering 31 (2011) 1833-1838

[11] Omid Mahian, Ali Kianifar, Clement Kleinstreuer, Moh'd A. Al-Nimr, Ioan Pop, Ahmet Z. Sahin, SomchaiWongwises A review of entropy generation in nanofluid flow International Journal of Heat and Mass Transfer 65 (2013) 514–532

[12] Wang. X and Mujumdar. A, 2008, A Review on Nanofluids Part I: Theoretical and Numerical Investigations, Brazilian Journal of Chemmical Engineering, 25 (4), pp. 613-630.

[13] Evans, W,Fish, J.and Keblinski, P.2006, "Role of Brownian Motion Hydrodynamics on Nanofluid Thermal Conductivity," Appl. Phys. Lett., 88(9), 093116-3.

[14] Keblinski, P., Prasher, R., and Eapen, J., 2008, "Thermal Conductance of Nanofluids: Is the Controversy Over" J. Nanopart. Res., 10(7), pp. 1089-1097.

[15] B. Farajollahi, S.Gh. Etemad, M. Hojj at Heat transfer of nanofluids in a shell and tube heat exchanger International Journal of Heat and Mass Transfer 53 (2010) 12–17

[16] Alhassan Salami Tijani, Ahmad Suhail bin SudirmanThermos-physical properties and heat transfer characteristics of water/anti-freezing and Al2O3/CuO based nanofluid as a coolant for car radiator International Journal of Heat and Mass Transfer 118 (2018) 48–57

[17] S. Suresh, K.P. Venkitaraj, P. Selvakumar, M. Chandra sekar, Effect of Al2O3–Cu/water hybrid nanofluid in heat transfer Experimental Thermal and Fluid Science 38 (2012) 54–60

[18] Mohamed M. Tawfik Experimental studies of nanofluid thermal conductivity enhancement and applications: A review Renewable and Sustainable Energy Reviews

[19] P M Sonawane, M D Shende, V P Baisane Effect of Nanofluids on Heat Pipe Thermal Performance: A Review of the Recent Literature International Journal of Engineering and Applied Sciences ISSN: 2394-3661, Volume-3, Issue-1, January 2016

[20] Gaurav N. Deshpande Heat Transfer Enhancement by Nanofluid in a Spiral Tube Heat Exchanger Mantech publication Journal of Thermal Engineering and Technology Volume 2 Issue 2.

[21] J.C. Maxwell, A Treatise on Electricity and Magnetism, second Ed. Clarendon Press, Oxford, UK, 1881.

[22] Das and choi, Nanofluids Science and Technology, John Wiley & Sons, Inc. New Jersey. 2007.

[23] Y. Xuan, W. Roetzel, Conceptions for heat transfer correlation of nanofluids, Int. J.Heat Mass Transf. 43 (2000) 3701–3707