IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EXPERIMENTAL STUDY ON CAPABILITY OF NANO-FLUIDS TO ENHANCE HEAT TRANSFER COEFFICIENT ON DOUBLE PIPE HEAT EXCHANGER

[1] D.Viswanath,[2] Dr.B.ChandraMohana Reddy,

[1] M.Tech(R&AC-Student) Roll No.:18001D3125, [2] HOD, Associate Professor

[1]Mechanical Engineering Department,

[1]JNTUA College of Engineering –Anantapur(A.P), India

Abstract: In the present experimental investigation, an experimental test is conducted on double pipe heat exchanger to establish the capability of Nano-fluids. cold side of a double pipe Heat exchanger antifreeze is mixed in water to enhance the Heat Transfer Coefficient. Experiments are conducted using distilled water on hot fluid side and Nano-fluids on cold side of the Heat Exchanger. Nano-fluids are prepared with TiO_2 particles of 30 Nano meters size are dispersed in distilled water as per the standard procedures. The properties of these Nano-fluids are estimated using method of mixtures. Mass flow rate is measured using the collecting tank and stop clock. Friction factor is determined by the measured pressure drop across the test length of heat exchanger. The results are presented, enhancement of heat transfer is compared under the same set of operating conditions in tabular form of counter flow arrangement and heat transfer coefficient is compared in a counter flow arrangement with different methodologies. From the present experimental study it is concluded that by using Nano-fluids particles at 0.004% by volume Heat Transfer Coefficient increases from 15% to 45% when compared to pure Ethylene Glycol + Water in a double pipe heat exchanger in counter flow arrangement.

Index Terms – **Nano-fluids, ethylene glycol, water, heat exchanger,TiO_2**

I. INTRODUCTION

Experiment is conducted on double pipe heat exchanger, its function is to transfer the heat (thermal) energy between hot and cold fluids when it transfers from hot fluid inlet to hot fluid outlet and cold fluid inlet to cold fluid outlet with and without Nano fluids when both fluids moves in opposite direction to establish the capability of Nano-fluids in thermal contact at different temperatures. The hot and cold fluid stream concern of evaporation or condensation in a single or multi tube component of heat exchanger. The objective of heat exchanger is to recover or reject heat, or sterilize, pasteurize, fractionate, concentrate or control a process fluid and it involves heating or cooling of a fluid in a single or multi tube exchange of heat energy from fluid steams.. In the present experimental study an experimental test is conducted on double pipe heat exchanger to establish the capability of Nano-fluids. Antifreeze is mixed with water in cold side of a double pipe Heat exchanger to study the enhancement of Heat Transfer Coefficient, LMTD, Reynolds number, Nusselt number, pressure drop etc, by counter flow arrangement of heat exchanger

1.1 HEAT EXCHANGERS ACCORDNG TO FLOW DIRECTION

- **Parallel flow Heat Exchanger:** In parallel flow heat exchanger, the two fluids flow in same direction and parallel to each other.

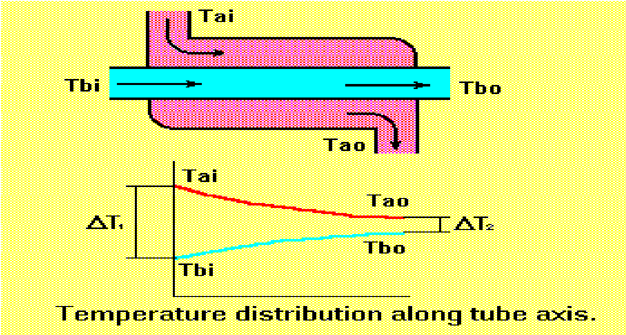


Fig 1: Parallel flow heat exchanger

- **Counter flow heat exchanger**

In a counter flow heat exchanger the two fluids flow parallel to each other but in opposite directions within the core. The counter flow arrangement is superior to any other flow arrangement and it is efficient flow arrangement for producing the highest temperature change in each fluid compared to any other fluid flow arrangement.

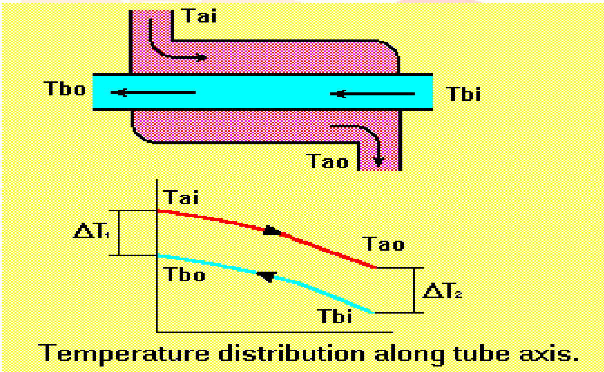


Fig 2: Counter flow heat exchanger

- **Cross flow Heat Exchanger:** In a cross-flow heat exchanger the direction of fluids are perpendicular to each other

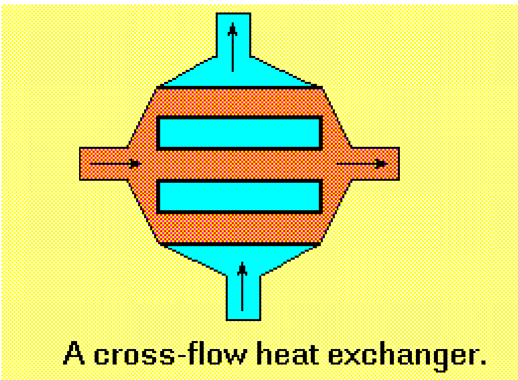


Fig 3: Cross flow heat exchanger

1.2 ANTI FREEZING AGENTS

Water based liquid freezing point can be lowered by the Antifreeze chemical additive.Freezing and boiling points are colligative properties of a solution, which depend on the concentration of the dissolved substance. Solution colligative properties are freezing and boiling points and these are depends on dissolved substance concentration.The purpose of antifreeze is to prevent a rigid enclosure from undergoing catastrophic deformation due to expansion when water turns to ice, because water has good antifreeze mixture properties as a Ethylene Glycol + Water, antifreeze is used to achieve freezing-point depression for cold environments and also achieves boiling point elevation ("anti-boil") to allow higher Ethylene Glycol + Water temperature.

Antifreeze typically contains ethylene glycol as its active ingredient. A modern Ethylene Glycol + Water /antifreeze have the excellent features like Corrosion prevention, Excellent heat transfer, Protection from freezing, Prevention of scale build up, Stability at high temperature, Compatibility with plastics and elastomers used in the engine, Low foaming

- **Ethylene glycol as anti freezing agent**

The widespread use of ethylene glycol as antifreeze is based on its ability to lower the freezing point when mixed water.

Ethylene glycol (IUPAC name: ethane-1,2-diol)

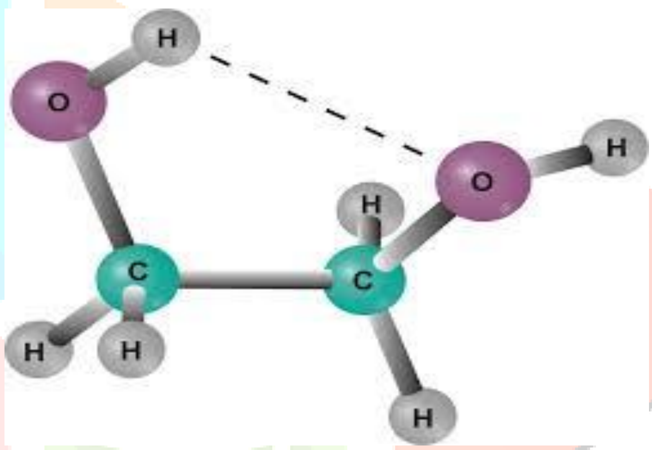


Fig 4: Figure of ethylene glycol

Table1: Physical properties of ethylene glycol

Boiling point at 101.3 kPa	197.60 ^{0}C
Freezing point	-13.00 ^{0}C
Density at 20 ^{0}C	1.1135 g/cm^{3}
Refractive index, n_D^{20}	1.4318
Heat of vaporization at 101.3 kPa	52.24 kJ/mol
Heat of combustion	19.07 MJ/kg
Critical temperature	372 ^{0}C
Critical pressure	6515.73 kPa
Critical volume	0.186 L/mol
Flash point	111 ^{0}C
Ignition temperature	410 $^{\circ}$C
Lower explosive limit	3.20 vol%
Upper explosive limit	53 vol%
Viscosity at 20 ^{0}C	19.83 mPa.s
Cubic expansion coefficient at 20 ^{0}C	0.62×10^{-3} K^{-1}

1.3 INTRODUCTION TO NANO FLUIDS

Fluids have poor heat transfer properties as compared with most solids which is the primary hindrance of high compactness and the effectiveness of the heat exchanger. An innovative way of improving the thermal conductivities of common fluids is to suspend small solid particles in the fluids. These suspended solid particles are at high thermal conductivities several hundreds of times greater than all of the conventional fluids combined. To form slurries from particle of various types like metallic, non-metallic and polymeric are added into these fluids. In the various industrial fields for improvements thermal conductivity and suspension stability both are required. A new class of fluid to motivate these two leads to development of nanofluids. A new kind of fluid is a Nanofluid which consists of uniformly dispersed and suspended nanometer-sized particles or fibers in fluids and has unprecedented thermal characteristics. Nano-powders have a combination of small particles size, narrow size distribution and high surface area to volume ratio. The physical and chemical properties of these nanoparticles often deviate from their bulk materials when the particle size decreases to a specific regime. The nanoparticles materials used in nanofluids are oxide ceramics (TiO2, Al2O3, CuO), nitride ceramics (AIN, SiN), carbide ceramics (SiC, TiC), metals (Ag, Au, Cu, Fe), semiconductors (TiO2), single or double or multi walled carbon nanotubes (SWCNT, DWCNT, MWCNT), and composite materials such as nanoparticles core polymer shell composites. These materials can be utilized to develop stable suspensions with enhanced flow, heat-transfer and other characteristics

Table2: Properties of Titanium dioxide (TiO_2):

Particle size	<25nm
specific surface area	200-220m^2/g
Density	3.94g/cc at 25ºC
Bulk density	0.04-0.06g/cc
Melting point	1825ºC

2. EXPEIMENTAL SETUP

The experimental setup, it consists of a test section two reservoir tanks, a hot water pump, a cold water pump, a cold water tank, a hot water tank, and a collection tank. The test section is 1.5m long counter flow horizontal double tube heat exchanger with nanofluid flowing inside the tube while the hot flows inside the annular. The inner tube is made from smooth copper tubing with a 9.53mm outer diameter and 8.13mm inner diameter, while the outer tube is made from PVC tubing and has a 33.9mm outer diameter and 27.8mm inner diameter. The test section is thermally isolated in order to reduce the heat loss along the axial direction. The J-type thermocouple mounted at both the ends test section to measure the bulk temperature of a nanofluid. The inlet and exit temperatures measured using J-type thermocouples which are inserted into the flow directly. During the test run, the inlet and exit temperatures of the hot water and nanofluids are measured and also mass flow rates of hot water and nanofluid are measured.

Fig 5: Experimental setup

Maximum heater input = 100W
Two collecting tanks of capacity = 50 liters.
Pump Specifications:
Discharge: 3200lit/hr
Power: 370 watts/0.5 hp

2.1 EXPERIMENTAL PROCEDURE

The first step in the experiment is to determine the overall heat transfer coefficient of base fluid or Ethylene Glycol + Water.

- 40%+60% by weight of Ethylene Glycol + Water are taken respectively to form a mixture. This Ethylene Glycol + Water mixture thus prepared is passed through the inner tube of the heat exchanger and hot water is passed through the annulus
- After the Nanofluid has been prepared, the cooling medium is replaced by nanofluid (TiO_2) and experiment is conducted by allowing hot water to flow into the annular spacing and nanofluid to flow into the inner copper tubing in a double pipe counter flow heat exchanger for heat transfer to take place.
- After attaining steady state, the inlet and outlet temperature readings of hot and nanofluid (cooling medium) are noted and with these readings the overall heat transfer is calculated by using LMTD method.
- The density of the Nanofluids at different concentrations and different temperatures is determined theoretically.
- The specific Heat of the nanofluids is estimated based on empirical relations.

Table 3: weights of nano power and density of the nanofluid at various concentrations

Volume fractions	Weight of Titanium dioxide(TiO_2) in grams (Wt)	Mixture density (kg/m3) (ρ_m)
0.2%	118.4	1022.90
0.1%	59.1	1011.53
0.01%	5.91	1001.15
0.005%	2.955	1000.57
0.004%	2.364	1000.46
0.001%	0.591	1000.11

It can be seen from the above table that with an increase of concentration, the density of nanofluids as been found to increase accordingly.

Table.4: Specific heat of nano fluid at various concentrations

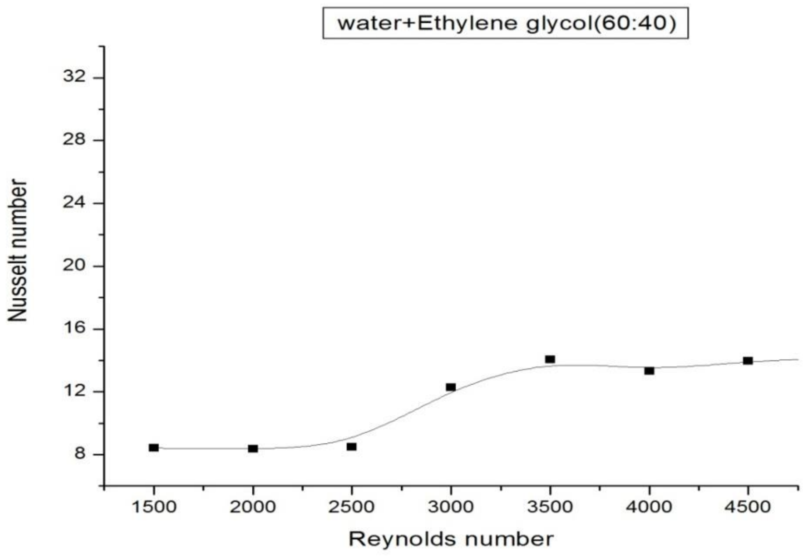
Volume concentration of nanoparticles in water	Specific heat of nano-fluid kJ/kg.k
0.003%	3.640684
0.004%	3.641036
0.005%	3.641800

2.2 EXPERIMENTAL DETAILS

- Convective heat transfer coefficient as a function of Reynolds number with various hot water flow rates are tabulated and compared
- Convective heat transfer coefficient as a function of Reynolds number with different nanofluid temperatures are tabulated and compared.
- Comparisons are made at different nanofluid temperatures for friction factor of water and nanofluid is tabulated.
- Comparisons are made for nanofluid pressure drop and water pressure drop are tabulated
- Comparisons are made at different nanofluid temperatures for friction factor of water and nanofluid.
- Comparisons are made for nanofluid pressure drop and water pressure drop are tabulated and graphs are plotted.

Table 5: Experimental observation for Ethylene Glycol + Water (40:60)

S.n	Temperatures (˚c)				Heat gained by cold fluid (Qc)	LMTD (˚c)	Heat transfer coefficient (h) W/m2K	Reynolds number (Re)	Nusselt number (Nu)	Pressure drop (ΔP)	Friction factor (f)
	Hot fluid inlet (Thi)	Hot fluid outlet (Tho)	Cold fluid inlet (Tci)	Cold fluid outlet (Tco)							
1.	80	76.5	33	60	490.05	30.24	403.15	1150	8.42	105.95	0.15
2.	80	76.5	37	53.5	524.08	32.56	400.42	2000	8.36	105.95	0.05
3.	80	76	37	54	647.95	32.06	406.67	2500	8.49	141.26	0.045
4.	80	76	40	55	713.29	30.166	588.24	3000	12.28	176.58	0.036
5.	80	76	40	55	816.75	30.166	673.56	3500	14.07	35.31	0.005
6.	80	75.5	39	52	821.1	32.06	637.14	4000	13.31	105.95	0.012
7.	80	75.5	40	52	849.4	31.60	668.7	4500	13.97	70.63	0.006
8.	80	75	40	51	870.47	31.91	678.8	5000	14.17	176.68	0.0131



Graph1: Nusselt number Vs Reynolds number for Ethylene Glycol + Water (40:60)

Table6: Experimental Observations for Ethylene Glycol + Water + Nano particles at 0.004% Volume fraction

S. n	Temperatures (˚c)				Qc	LMTD (˚c)	(h) W/m2K	Reynolds number (Re)	Nusselt number (Nu)	Pressure drop (ΔP)	Friction factor (f)	Enhanceme nt ratio
	Thi	Tho	Tci	Tco								
1.	80	77	33	56	418.6	32.99	315.66	1150	6.55	133.4	0.198	0.778
2.	80	76.8	39	56	541.45	30.38	443.4	2000	9.19	133.4	0.0648	1.099
3.	80	76.6	33	52	726.18	35.23	512.79	2500	10.63	266.8	0.0906	1.252
4.	80	76.4	39.5	55.4	758.17	30.34	621.66	3000	12.89	400.2	0.0867	1.049
5.	80	77	40	54.5	796.74	30.89	641.66	3500	13.31	533.6	0.0864	0.946
6.	80	76	33	48	950.04	37.23	634.83	4000	13.16	667	0.0810	1.000
7.	80	75.9	33	45.1	1000.8	37.67	660.9	4500	13.7	667	0.0652	0.981
8.	80	76	34.5	48	1071.25	36.45	731.14	5000	15.16	667	0.0522	1.070

Convective heat transfer coefficient as a function of Reynolds number with various hot water flow rates and also it is a function of Reynolds number with Nano particles at 0.004% Volume fraction. From the experimental values results are tabulated and compared

Thi: temperature of hot fluid inlet to heat exchanger-(˚c)

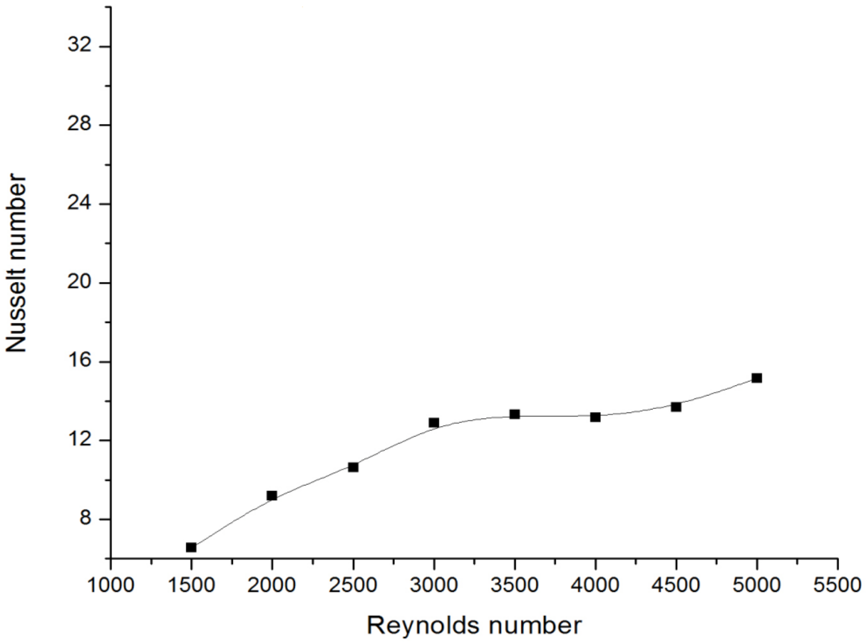
Tho: temperature of hot fluid out let from heat exchanger--(˚c)

Tci: temperature of cold fluid inlet to heat exchanger--(˚c)

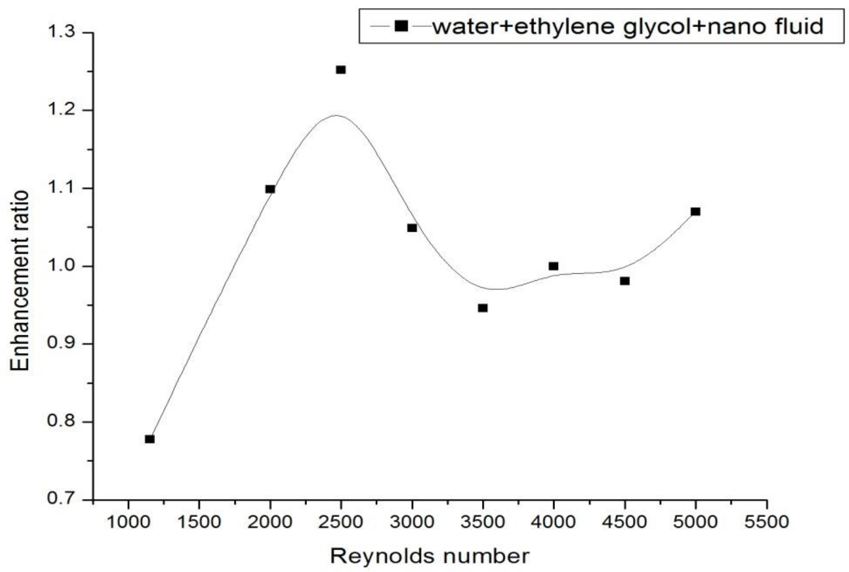
Tco: temperature of cold fluid out let from heat exchanger--(˚c)

(Qc) :Heat gained by cold fluid

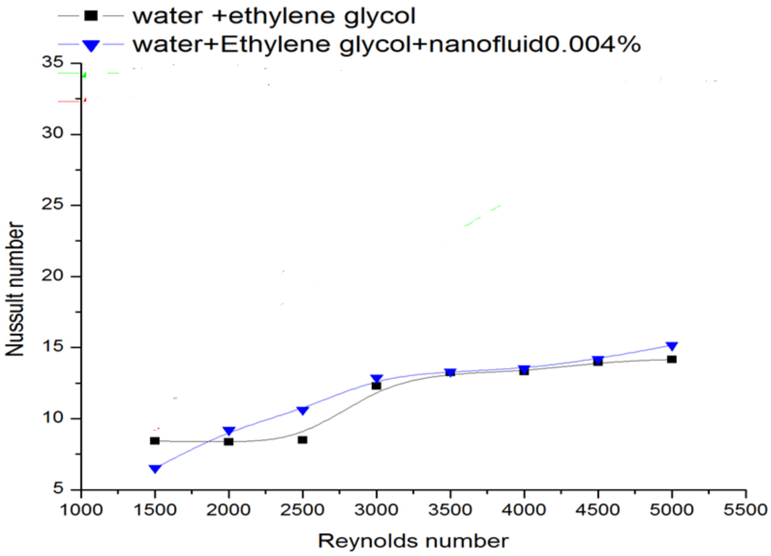
h: Heat transfer coefficient- W/m2K



Graph2: Nusselt number Vs Reynolds number of Nano fluids (Ethylene Glycol + Water with Nano particles



Graph3: Enhancement ratio Vs Reynolds number of Nano fluids (Ethylene Glycol + Water with Nano particles)



Graph4: Nusselt number Vs Reynolds number of water + ethylene glycol and water + Ethylene Glycol + Nano fluid 0.004%

3. CONCLUSIONS

- At very low concentration of nano particles (nano fluids) higher thermal conductivity is observed and the considerable enhancement convective heat transfer coefficient, which is generally higher than that of effective thermal conductivity
- The enhancement of overall heat transfer coefficient compared to the base fluids increases from 5% to10% with use of 0.004 % volume TiO2 nanoparticles concentration.
- Nanofluids with relatively small concentration of solid particles exhibited enhancement of Overall heat transfer coefficient.
- It was observed from table-1 values and graph-1 up to 2500 Reynolds number of Ethylene Glycol + Water (40:60)Nusult number not increased much and then it started increasing with the increase of Reynolds number.
- It was observed from the graph-2 with Nano fluids up to 1500 Reynolds number there is no rise of nusselt number and then increase of nusselt number observed
- It was observed for the graph-3 the maximum Enhancement ratio is obtained upto the Reynolds number 2500 and then the curve started decreased with the increase of Reynolds number

4. SCOPE FOR THE FUTURE WORK

- As a result, an important need still exists to develop new strategies in order to improve the effective heat transfer behaviors of conventional fluids by mixing nano particals. Based on results observed that the Nanofluids can allow the optimum temperature but still some more studies required to investigate the effect of overall heat transfer coefficient at different Reynolds numbers particularly to consider the future design components of Refrigeration and Air conditioning also in the field of Automobile radiators design to transfer heat by reducing size and weight of radiator. .
- Heat transfer coefficient ratio against Reynolds number also has the scope for further study.
- Convective heat transfer coefficient as a function of Reynolds number with various hot water flow rate and function of Reynolds number with different nano fluid temperatures so still it has a lot of scope for the future work to Comparison of friction factor of water and nano fluid and also for Comparison of nano fluid pressure drop and water pressure drop.

REFERENCES

[1] Y. Xuan, Q. Li, "Investigation on convective heat transfer and flow features of nanofluids", ASME J. Heat Transfer 125 (2003) 151.

[2] S.K. Das, N. Putta, P. Thiesen, W. Roetzel, "Temperature dependence of thermal conductivity enhancement for nanofluids", ASME Trans. J. Heat Transfer 125 (2003) 567.

[3] D. Wen, Y. Ding, "Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions", Int. J. Heat Mass Transfer 47 (2004) 5181.

[4] Y. Yang, Z.G. Zhang, E.A. Grulke, W.B. Anderson, G. Wu, "Heat transfer properties of nanoparticle-in-fluid dispersions (nanofluids) in laminar flow", Int. J. Heat Mass Transfer 48 (6) (2005) 1107.

[5] Y. Ding, H. Alias, D. Wen, R.A. Williams, "Heat transfer of aqueous suspensions of carbon nanotubes (CNT nanofluids)", Int. J. Heat Mass Transfer 49 (1–2) (2005) 240.

[6] S.M.S. Murshed, K.C. Leong, C. Yang, "Enhanced thermal conductivity of TiO2–water based nanofluids", Int. J. Therm. Sci. 44 (2005) 367.

[7] S.Z. Heris, S.G. Etemad, M.N. Esfahany, "Experimental investigation of oxide nanofluids laminar flow convective heat transfe"r, Int. Commun. Heat Mass Transfer 33 (2006) 529.

[8] X.Q. Wang, A.S. Mujumdar, "Heat transfer characteristics of nanofluids: aReview", Int. J. Therm. Sci. 46 (2007) 1.

[9] S.Z. Heris, M.N. Esfahany, S.G. Etemad, "Experimental investigation ofConvective heat transfer of Al2O3/water nanofluid in circular tube", Int. J. HeatFluids Flow 28 (2) (2007) 203.

[10] Y. He, Y. Jin, H. Chen, Y. Ding, D. Cang, H. Lu, "Heat transfer and flow behavior of aqueous suspensions of TiO2 nanoparticles (nanofluids) flowing upward through a vertical pipe", Int. J. Heat Mass Transfer 50 (2007) 2272.

[11] C.T. Nguyen, G. Roy, C. Gauthier, N. Galanis, "Heat transfer enhancement using Al2O3–water nanofluid for electronic liquid cooling system", Appl. Therm. Eng. 28 (2007) 1501.

[12] Naga Sarada.S, Sita Rama Raju.A.V, Kalyani Radha.K, Shyam Sundar.L, "Enhancement of heat transfer using varying width twisted tape inserts", International Journal of Engineering, Science and Technology, 2010, volume 2, Issue6, pp.107-118.

[13] Sunil Jamra, Pravin Kumar Singh & Pankaj dubey, "Experimental analysis of heat transfer enhancement in circular double tube heat exchanger using inserts", International Journal of Mechanical Engineering andTechnology, 2012, volume 3, Issue3, pp.306-314.

[14]. Dhamne.N.B, Nalawade. D.B, Dange. M.M, "Experimental study of heat transfer for wavy twisted tape insert of variouspitches placed in a circular tape", International Journal of Innovative Research and Development, Feb2014, volume 3, Issue-2.

[15] Mayank Bhola,B, Vinod Kumar, Satyendra Singh, "Heat Transfer Enhancement in Concentric Tube Heat Exchanger in ANSYS FLUENT" , InternationalJournal of Engineering Research & Technology (IJERT) ISSN: 2278-0181,IJERTV4IS040092 ,www.ijert.org - Vol. 4 Issue 04, April-2015

[16] K.Vijaya Kumar Reddy, Naga Sarada Somanchi B. Sudheer Prem Kumar, "Heat transfer enhancement in a double pipe heat exchanger using nano fluids" ,Conference Paper · October 2015 Proceedings of the 17th ISME Conference ISME17 October 3-4, 2015, IIT Delhi, New Delhi

[17] M. A. Boda, M. RamachandranS. S. Deshetti, M. A. Gavade, "Advanced Heat Transfer Enhancement by using Nanofluids, A Review", ISSN: 2231-5381 International Journal of Engineering Trends and Technology (IJETT) – Volume-45 Number-8 -March 2017

[18] Chitti Babu Gaddem, Raffi Mohammed, Dr. Bh Vara Prasad "CFD Analysis of Enhancement of Turbulent Flow Heat Transferin a Horizontal Circular Tube with Twisted Tape Inserts" International Journal for Research in Applied Science & Engineering Technology (IJRASET**),**ISSN: 2321-9653; Volume 6 Issue I, January 2018- www.ijraset.com

[19] Bipin Kumar,Manoj Kumar,Anil Kumar Patil ,Siddharth Jain"Effect of V cut in perforated twisted tape insert on heat transfer and fluid flow behavior of tube flow: An experimental study" Pages 524-544 |Nov 2018, https://doi.org/10.1080/08916152.2018.1545808