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Preparation and Investigation of Heat Transfer Rate by using MgO-Nanofluid in Pipe-in-Pipe Heat Exchanger

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Abstract: In a world full of machines and industries, energy is always in demand for which engineers often look for new technologies and approaches to build the efficiencies of the machines and their outputs as a result of it there is rise in establishments of power plants, natural gas processing, petroleum refineries, etc. where they produce tremendous measure of vitality required for the daily basis. Heat exchangers being part of them plays a major role in the energy generation. They are mainly known for their purpose of transferring heat from hot liquid to cold liquids, or can be simply said as the exchange of heat between two different fluids, as there is strive for increase in efficiencies and outputs of the plants, heat exchangers are considered as the key to those solutions i.e. the efficiencies of plant can be increased by increasing the efficiency of the heat exchangers. This can be done in a numerous ways one of them is the utilization of Nano liquids as base liquid for Heat Exchangers. Nano fluids constitute a vital part in the addition of heat transfer, they are also considered to be the one of the primary reasons for increasing in efficiency of the performance of heat exchanger. In our project what we are doing is that we are replacing normal water as cold fluid with MgO Nano fluids as base fluid and perform the experiment on pipe in pipe heat exchanger and study their effects in heat exchanger performance. We will contemplate the heat transfer rate, heat transfer coefficient and compare the results of MgO, and water when used as base fluid. Here we consider different outputs by working at two different hot fluid inlet temperatures and two different MgO volume concentrations and tabulate the results comparing 2 base fluids i.e. magnesium oxide Nano fluid, normal pure water.
Keywords: Heat exchanger, Nanofluids, Base fluid, Overall heat transfer coefficient.

List of symbols

A	Surface Area of the pipe
α	thermal diffusivity
C_p	Specific heat
C.W	Cooling Water (in °C)
H.W	Hot Water (in °C)
I/L	Inlet
LMTD	Log Mean Temperature Difference
m_w	Mass flow rate
O/L	Outlet
Q	Amount of Heat transferred
T	Total Temperature Difference
t_m	Mean temperature (in °C)
U	Overall Heat Transfer Coefficient
V	Viscosity
ΔT	Difference in TemperatureK
Θ_1	Initial temperature difference (I.T.D) (in °C)
Θ_2	Terminal temperature difference (T.T.D) (in °C)
P	Density
k	Thermal conductivity
μ	Viscosity

Cp_{nf}	specific heat capacity of nanofluid
Re	Reynolds number
Nu	Nusselt number

I. INRODUCTION AND LITERATURE REVIEW

A. Introduction to heat exchangers

As referred earlier in the abstract heat exchangers are utilized in almost everywhere they are assumed to be a key part in air conditioners, refrigerators, power plants, petrochemical plants, refineries, etc. They are mostly seen in thermal power plants their main role is the transfer of heat between 2 different fluids or can be explained as transfer of heat from hot liquid to cold liquid by using the principle of conduction. There are different types of heat exchangers like

1) Shell and tube heat exchanger
2) Pipe in pipe heat exchanger
3) Plate heat exchangers
4) Regenerative heat exchanger, etc.

Fig1.1 shell and tube heat exchanger

Fig1.2 pipe in pipe heat exchanger

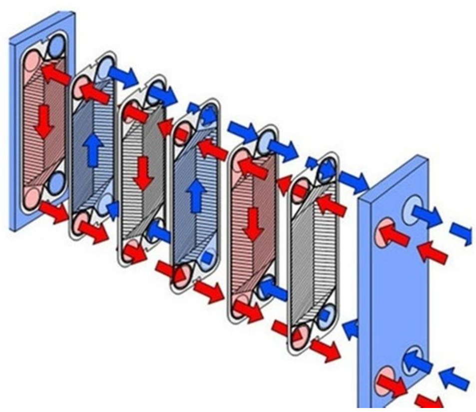

Fig1.3 plate type heat exchanger

Out of them shell and tube heat exchanger and pipe in pipe heat exchanger are opted more for the performance of experiments, it is because of the different properties like, weight, feasibility, quality, etc. most of the heat exchangers are made of aluminium as a result of its light weight, thermal conductivity, durability, etc. flow rate also one of the factor that needs to be considered while using heat exchanger there are 2 different types of flow rates they are

5) Parallel flow
6) Counter flow

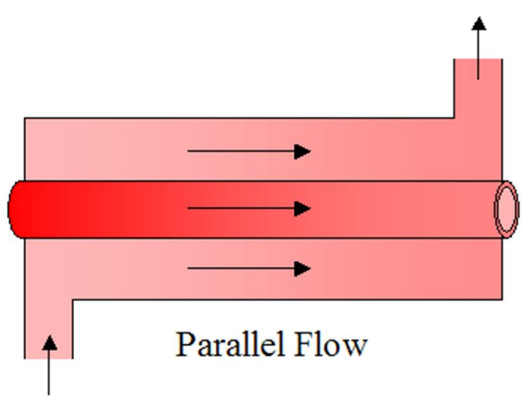

Fig1.4 parallel flow

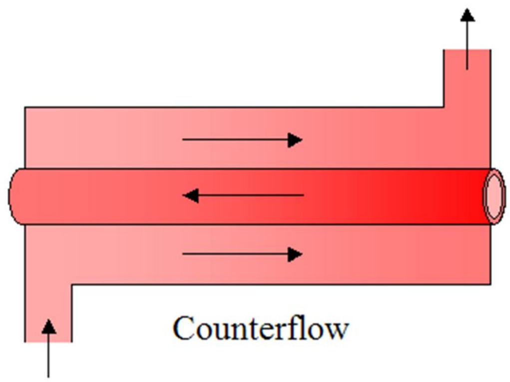

Fig1.5 counter flow

Parallel flow refers to the direction of flow of base fluid and hot liquid needs to be in same direction whereas counter flow results in opposite flow direction of base fluid and hot fluid

II. INTRODUCTION TO NANO FLUIDS

Nano fluids are not directly available; they have to be prepared from Nano particles this is actually done by two-step method. Nano particles to be used in the procedure initially delivered as dry powders by chemical or PHysical strategies. Initially triton x-100 surfactant is added to the normal water and kept under sonication for a span of 20 min this agitates the particles in the liquid and loosen up the particles sticking to the surfaces and the surfactant used for dispersion of the particles that are suspended and prevent agglomeration and also help in stabilizing the fluid .Then, the Nano measured powder will be scattered into a liquid in the second handling venture with the assistance of escalated attractive magnetic force agitation, ultrasonic agitation, high-shear blending, homogenizing and ball processing. Two-step method is the most economic method to give or deliver Nano fluids in extensive scale Efficiency of the heat exchanger is a big concern in many industries, usage of these Nano fluids in the heat exchanger increase the thermal capacity of base fluid which intern increases the amount of heat flow which results in increase in the efficiency of the heat exchanger. Here, we are going to carry out the experiment using these Nano fluids by passing them through the heat exchanger there by calculating the results based on the output.

Fig1.6 MgO Nano particles

Fig1.7 prepared Nano fluids

A. Sonication

Sonication is the process of exposing the water or Nano fluid to the ultra-sonic rays in a closed space for certain amount of time. It is used to agitate the particles in the fluid and help cleaning- loosening the particles that are adhering or that are sticking to the surface. The total amount of energy delivered to the Nano fluid of all concentration levels is same. During the sonication process we can observe the increase in temperature of the liquid, so we have to take care of this aspect as it may effect the concentration of the Nano fluid. The quality of the Nano fluid relies on the Sonication time apart from the surfactant and the PH levels of the fluid. The Nano particles sedimentation is directly proportional to sonication time, if the particles get suspended at the bottom then it indicates the lack of sonication time. so the sonication time plays an important role in the Nano fluid preparation. The effects of sonication time can be explained by the following fig

Fig 1.8 sonicator

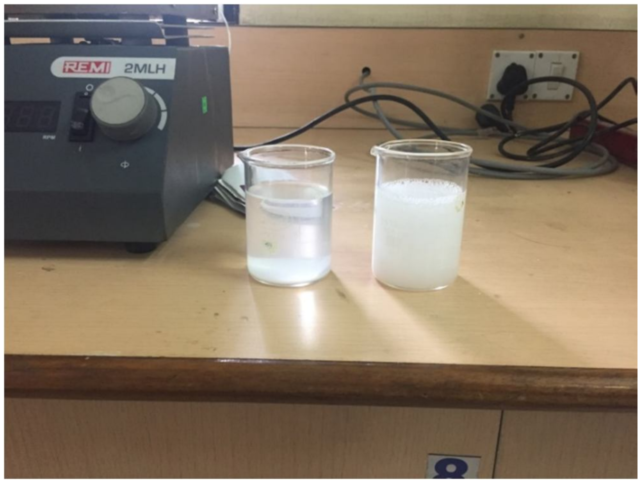

Fig1.9 suspension of Nano particles based on time

Here in the above fig1.9 we can see that Nano particles got suspended at the bottom of the container for the sample which has been under sonication for 40min whereas the Nano particles didn't get suspend in the next sample as it is undergone sonication for 3 hrs.so therefore we can say that the suspension of Nano particles in the fluid relies on the sonication time

B. Magnetic Stirrer

Magnetic stirrer also considered as one of the main equipment for the preparation of Nano fluid. After the sonication of the normal water in the presence of surfactant for about 20 min then it is the duty of the magnetic stirrer to ensure that the Nano particles get mixed properly without stagnation. The magnetic stirrer consists of a magnetic pellet and a temperature control probe attached to a temperature measuring unit. the pellet revolves as soon as the machine is switched on and min temperature should be maintained so as to keep the particles getting mixed and prevent the stagnentation of the Nano particles. It ensures that the mixture is well mixed and should be in a homogeneous state so as there should be no suspension of the Nano particles at the bottom of the container. This process has to be done from 10-20 min based on the concentration level and the Nano particle size , after this process the prepared Nano fluid is again undergoes the sonication for 2-3 hrs.so that the particles don't get settled at the bottom of the container

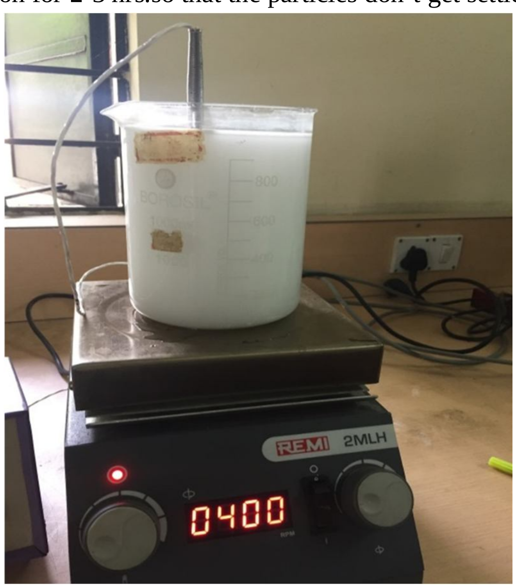

Fig1.10 magnetic stirrer

C. Literature review

Dr. Zena Kadhim et.al.(2016)Experimental investigations have been conducted regarding the enhancement of heat transfer attributes for cross stream flow low integral finned tube heat exchanger with utilizing the MgO Nano fluid. In this process they used magnesium of 40nm diameter size was dispersed in distilled water of 0.15%, 0.35%.0.55%.0.75% by volume is utilized for preparation of Nano fluid. here in this experiment air is used as the cooling fluid the is made to pass across the test tube with different velocities and for the inner side flow we have taken different velocities for water and the Nano fluid as a result we have found that the thermal conductivity and the density of the fluid are observed to be enhanced i.e. increased and also enhancement of heat transfer characteristics when used Nano fluids.Gurbir Singh, Hemant Kumar et.al.(2014) have produced a research paper on the shell and tube heat exchanger which describes the change in temperature and Various parameters using computation fluid dynamics (CFD) in this paper they have explained the different changes that occur in heat exchanger utilizing different flow rates i.e. for 2l/min and 3l/min and have explained the changes that occur in temperature , pressure etc. when taken different flow rates, simultaneously told the uses and the significance of CFD which is used for calculating different parameters that cannot be achieved in different conditions practically. Ramtin Barzegarian, Aloueyan A, Yousefi Tet.al (2017) In this paper an experiment was carried on Shell and tube heat exchanger with segmental baffels, using Al2O3 as nano fluid (Al2O3-gamma nanoparticles with 15 nm mean diameter) they have studied on the effect of some parameters of hot working fluid such as Reynolds number and volume concentration of nanoparticles on heat transfer characteristics, friction factor and thermal performance factor of a shell and tube heat exchanger under laminar flow regime is investigated. The results were tabulated based in the increase in the nusselt number and overall heat transfer coefficient of the heat exchanger by the increase in the Reynolds number. It was found out that at certain Reynolds number the heat transfer coefficient increases as there is an increase in the concentration of the nano particles.. Jurij Avsec and Maks Oblak et.al.(2005)In this research paper they showed us how to ascertain the thermal conductivity of Nano particles suspended in a liquid analytically , they have opted the formula given by HAMILTON and CROSSER in which the thermal conductivity of a Nano particle can be calculated according to that formula in this research paper they have made an assumption that the thermal conductivity increment in Nano fluids is because of the liquid layers around the Nano particles they have also used xue theory for further simplicity.L.B mapa et.al. (2005) Measured the increase in thermal conductivity of copper-water based Nano fluid by the utilization of a shell and tube heat exchanger. The results of investigation i.e. analysis is rate of heat transfer is increases with incrementing flow rate and also its concentration. Shuichi tori et.al.(2007) with the help of heat tube apparatus and utilizing the diamond based Nano fluid the convective heat transfer coefficient is investigated .This revealed that heat transfer coefficient increases with concentration and Reynolds number of Nano fluid. Manjnath., Vinshnu Prasad, Sandeep et al(2007) Comparison of CFD analysis and experimental analysis of Titanium-oxide water in the Heat Exchanger. It is found that Thermal conductivity of Nano fluid increases constantly by increasing the titanium concentration from 1 to 3gms. Sandeep patel et al(2004) The paper mainly concentrate on the study of heat exchanger and the various factors affecting the performance of a shell and tube heat exchanger. Martin, Arnold et al.(2004) Theoretically analysed the heat transfer of Nanoparticle suspensions in turbulent stream pipe flow. They considered Nano fluids act more like single-stage fluids than like conventional solid-liquid blends. They showed the existence of an ideal particle stacking for either maximum heat transfer at steady driving power or Minimum cost of activity at consistent heat transfer rate. Rahimi-Esbo etal.(2016) Numerically examined the turbulent constrained (forced) convection jet flow of Nano liquid in a converging channel. They showed that by increasing the volume fraction from 0% to 5%, the average Nu on the down wall is enhanced by more than 8%.Parish Rawal, Mohan Singh et al.(2009) Conducted an experimental and theoretical study to explore heat transfer and flow for Nano fluid in inclined and horizontal circular tube heated by a uniform axial heat (transition) flux, flow laminar. Here they have used three different types of Nano fluids of different sizes they are as follows, Al of 25nm, CuO of 50nm and Al2O3 of 30nm. The values of NuR were assumed to be 45%, 31% and 25% for the following Al, Al2O3 and CuO Nano fluid, with the uniform constant heat flux and constant wall temperature. XUAN and LI et al.(2000) Have undergone a careful consideration of the heat transfer for a turbulent flow of Nano liquid inner side of a tube. They investigated Copper-water Nano fluid in a heat exchanger of 10 mm inner diameter and straight (linear) brass tube with 800 mm of length. They have established that, the heat transfer coefficient of Nano fluids constituting of 2% Cu Nano particles was increased by 40% with the combination to that of water. For the calculation of Nussle number inside a tube they predicted a correlation for turbulent flow of Nano fluid Eastman et al.(2007) Average diameter of copper Nano particles is smaller than 10 nm. For Al2O3 Nanoparticles that the average diameter is 35nm the carbon Nanotubes have grabbed much attention due to of their unique structure and remarkable mechanical and electrical properties. Faruk Kiliça, Tayfun Menlikb, Adnan Sözenb at.el (2004) in this research paper we have seen the study of effect of titanium Nano fluid on the thermal performance on flat plate solar collector, their main aim is to increase the thermal efficiency using the Nano fluids which it has to be manually prepared, they have considered 2% TiO_2 to pure water mixture followed by the addition of triton x-100 of 0.2%wt ratio to prevent agglomeration. The whole solution have to be mixed continuously pulsing 8 hours in ultrasonic bath which is termed as sonication, this ends up the point of the preparation of Nano fluid there by helping in the increase in thermal performances . there is a difference of 12% increase in efficiency of using Nano fluid as compared to normal pure water. Gaweł Z_ yła at,el(2010) they have mainly concentrated on the viscosity and the thermal conductivity of the Nano liquids which are 2 main important properties of the Nano fluids , here they have taken magnesium oxide ethylene glycol (MgO-EG) .here for the calculation or for determination of thermal conductivity they opted for KD2 pro thermal property analyser , the increment in volume fraction of Nano particles increases the viscosity of the suspension dynamic viscosity is taken as constant in the examined ranges there by qualifying this Nano fluid as Newtonian materials. Usria, Azmia et.al(2007) this paper reflects about the comparison of the Al_2O_3 Nano fluid on the grounds of water and ethylene glycol (EG) here they have taken for 3 different volume ratios for both water and EG resulting in the calculation of the thermal conductivity using KD2 pro thermal property analyser , on the bases of it they have performed the experiment and have tabulated the values. Salman,Reza et al.(2017)In this paper they have taken bi particle Nano fluid containing Al_2O_3 and TiO_2, and two methods are followed in this one is the EMM extended Maxwell model , and the second one is PMM particle mapping model together using these two models they have given us the thermal conductivity vs. fractional particles volume concentration , and they have given a solution that the stability of the Nano fluid is the most affecting factor for the change in or the variations in thermal conductivity of the system .Gurbir Singh1, Hemant Kumar et al (2004) they have opted for the shell and tube heat exchanger where they have performed the analysis in CFD (computation fluid dynamics) which can be utilized to determine the heat transfer, velocity, viscosity, etc. of the base fluid i.e. water using ANSYS software , the reason for opting CFD is, it is more compatible as compared to experimental values . The software gives us almost the exact values and can also give results for some experiments that cannot be performed in real life. Here they have calculated for parallel as well as counter flow there by tabulating 2 different values and gave us the optimal solutions. Hafiz Muhammed Ali, Muhammed Danish et.al (2015) Prepared mgo Nano fluids of various concentrations (0.06%,0.09%&0.12%) and heat transfer is observed by testing it in a car radiator. They observed a maximum heat transfer increment of 31% at 0.12%. Periyasamy Mukesh kumar , Jegadeesan et al.(2014) In this review paper they have tabled down most of the theoretical models proposed to calculate the thermal conductivity. Consists of wide range of different formulas considering essential factors like shape factor, interaction between the Nanoparticles, temperature of base fluid, Size of the Nanoparticles. Sayantan Mukherjee et al.(2013) This review paper states the types of methods and steps followed in preparation of Nano fluids. It not only states about different single-step method proposed in the past and also about the two step method, prominently used and also commercial method, in which Nano powder is prepared separately by milling, sol-gel methods and then they are directly mixed with the base fluid. It also states the use of surfactants, magnetic stirring, ultra sonication techniques for stability of the Nano fluids. Qing-Zhong et al.(2013) put forward a prototype to determine the thermal conductivity of Al2O3/water Nano fluid, derived from Maxwell theory. He considered the interface between base-fluid and Nanoparticles in the model. The proposed formulae gives similar results to the experimental results. Mohammad Hemmat Esfe et al.(2015) They investigated the thermal conductivity of MgO/Water-EG mixture Nano fluid at 8 different concentrations laying from 0.1% to 3% by KD2 pro thermal analyser. It is to be observed that the thermal conductivity increases with the increment of volume fraction. From the results, they proposed a relationship for modelling the MgO/water-EG (60:40) thermal conductivity for various volume fractions.

D. Methodology And Experimental Procedure

1) Stages of execution

The fig show the schematic setup of the procedure

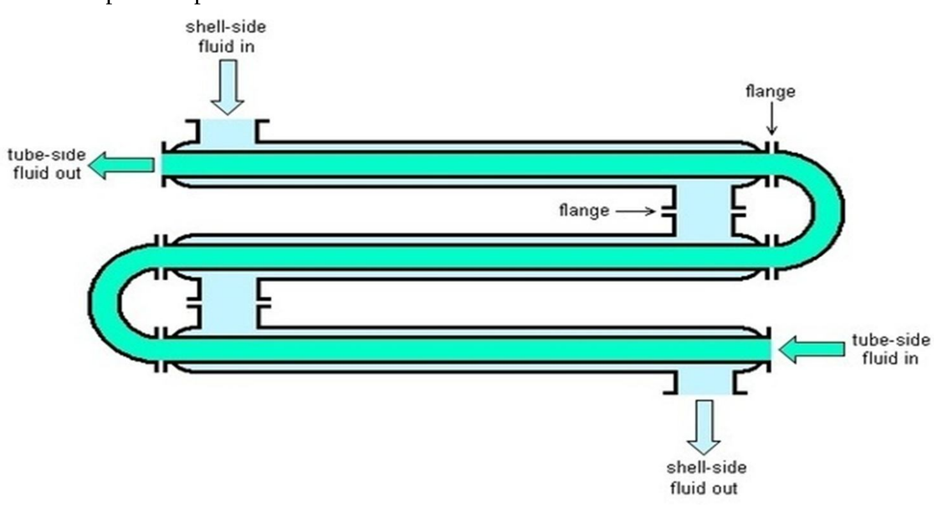

Fig2.1 schematic diagram of pipe in pipe heat exchanger.

Density, Cp, viscosity and thermal conductivity of Nano fluids are calculated manually by using standard formulas. Comparison is drawn between the working of MgO-Nano fluid and water fluids.

The whole project is done under different stages. Each stage constitute of different ways and all of them lead to the ultimate result of increasing the heat transfer of the heat exchanger the stages are as follows

a) *Stage-I* - preparation of Nano fluids
b) *Stage-II* **-** using the prepared Nano fluid in the heat exchanger and perform the experiment
c) *Stage-III* – calculations

The whole project is done in 3 stages as mentioned above the prepared Nano fluids are utilized as base fluid in heat exchanger there by calculating the heat transfer and its coefficient using the results obtained from the experiment now lets discuss them in brief

a) *Stage-I:* Preparation of Nano fluid is already explained in the above introduction. Initially the surfactant is added to water and kept in a sonicator for sonication of about 20 min. after that the Nano particles are introduced to the mixture and kept under the presence of magnetic stirrer for about 15-20min. after that the whole fluid is kept undergone sonication for about 3hrs so as to prevent the agglomeration and stagnation of Nano particles at the base (bottom) of the container. These are the steps followed in the preparation of Nano fluid
b) *Stage-II:* In this stage the prepared Nano fluids are used to perform experiment. This fluid is used for determining (calculating) the heat transfer rate and its coefficient based on the results obtained from the experiment. Here we consider the parallel flow where the hot liquid and the Nano fluid are passed in same direction. Initially the temperatures of hot liquid and Nano fluids is taken later the hot liquid output and Nano fluid outlet temperature is noted down , based on the input and output temperature differences the heat transfer rate and its coefficient is calculated.
c) *Stage-III:* Based on the above experiment readings calculations are made resulting in the heat transfer, etc

Different types of fluids used for analysis:

i. Magnesium oxide-water
ii. Pure water

2) *Mathematical formulation*

From the experimental readings taken and using the following formulas we narrow down the results.

a) $LMTD = \frac{(\theta 1 - \theta 2)}{ln\ (\theta 1/\ \theta 2)}$ K
b) Q=U × A × LMTD j/s
c) $m = \rho A V_0$ Kg/s
d) $Re = \rho VL/\ \mu$
e) $Nu=0.023\times (Re^{0.8})\times Pr^{0.3}=h\times D/K$
f) Nu = hL/k
g) $(1/UA)=(1/hi) + 1/(2\times 3.14\times L\times k)ln(r_o/r_i)$ $W/(m^2)\times k$
h) For Nanofluid properties calculation
   $\Phi=(Vnp/(Vnp+Vbf))\times 100$
i) $\rho_{nf} =(1- \Phi)f+\rho_{pq}$ kg/m^3
j) $K_{nf}/k_b =\{k_p+2k_b-2(k_b-k_p)\ \Phi\}/\ \{k_p+2k_b+2(k_b-k_p)\ \Phi\}$w/mk
k) $\mu_m = (1+2.5\ \Phi)\ \mu_b$ Pa.s
l) $Cp_{=\{\{(1-}\ \Phi_{)*(}\rho_{bf}\times Cp_{bf)\}+}\ \Phi(\rho_{np}\times Cp_{np})\}/\ \rho_{nf}$ KJ/kgK
m) $\alpha=k/(\rho\times Cp)$ m^2/s
n) $Pr=\mu/(\rho\times\alpha)$
o) Nu=0.074× (Re^0.707) × (Pr^0.385) × (Φ^0.074)

Fig 3.0 the above pipe in pipe heat exchanger is used for the experiment

We have 2 inlets (hot water inlet, cold water inlet) and 2 outlets (hot water outlet, cold water outlet)
so from the experiment carried out and based on the results calculated (sample calculation is shown above) so we get the following results as follows.Flow rates:Hot water-2lit/min;Cold water-5lit/min.

III. PURE WATER TAKEN AS BASE FLUID OR COLD INLET:

So from the experiment carried out we have tabulated the following results when pure water which we use for normal house hold works is taken as a cold water inlet in heat exchanger for which hot water temperatures taken as 55□ and 65□

Table 3.1 total results varying the hot fluid temperature and keeping the cold fluid temperature constant

s.no	Base liquid	Lmtd (k)	U(w/m^{2}k)	Q (kJ/sec)
1	Water-Water (Hot fluid inlet at 55□)	6.12	821.20	1.32
2	Water-Water at (Hot fluid inlet at 65□)	10.10	848.73	1.98
3	Water-MgO/water (%0.08 vol conc)(Hot fluid inlet at 55□)	5.04	828.70	1.81
4	Water-MgO/water (0.08%volconc)at(Hot fluid inlet at 65□)	6.90	851.18	2.42
5	Water-MgO/water (0.1% vol conc) at(Hot fluid at 55□)	3.99	831.77	2.14
6	Water-MgO/water (0.1% vol conc) at (Hot fluid inlet at65□)	5.71	852.26	2.58

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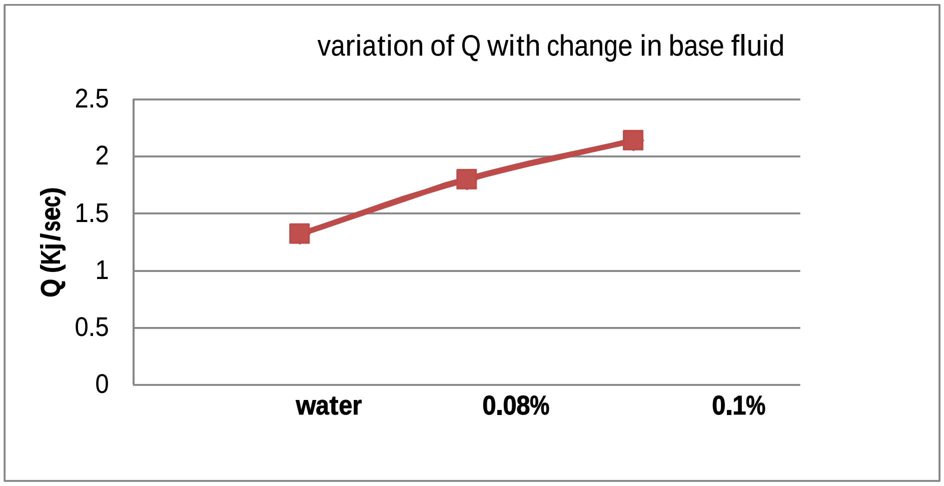

Fig 3.1 Variations in Q (kJ/s)

Variation in the Q (heat transfer rate) with different base fluids when taken inlet water temperasure at 55˚C

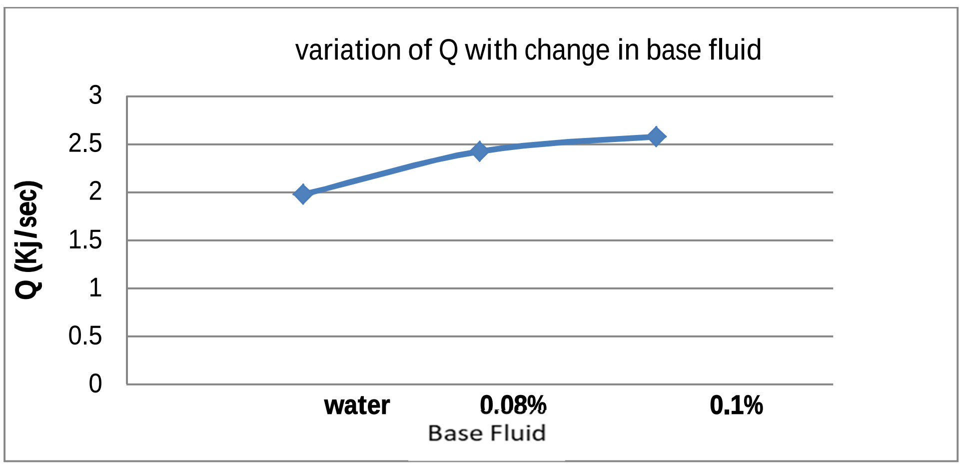

Fig 3.2 variation in Q(kJ/s)

Variation in the Q (heat transfer rate) with different base fluids when taken inlet kwater temperasure at 65˚

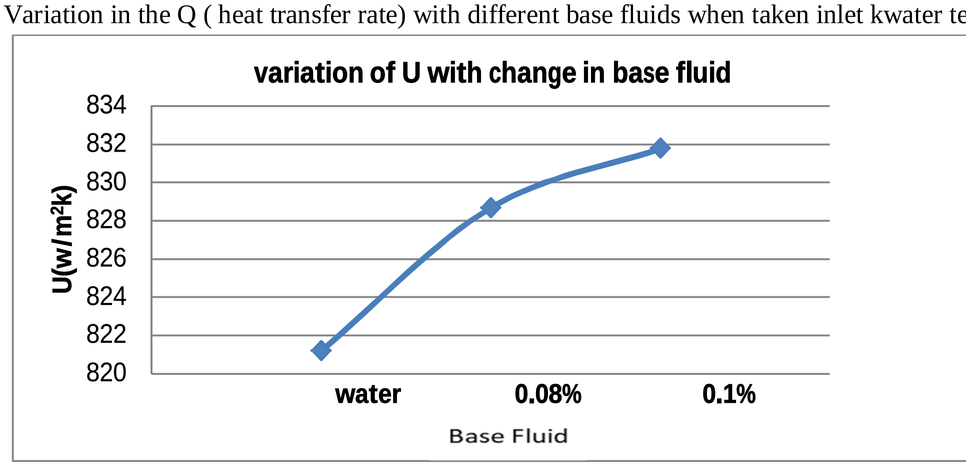

Fig 3.3 Graph determining U value

Variation in the U with different base fluids when taken inlet kwater temperasure at 55˚C

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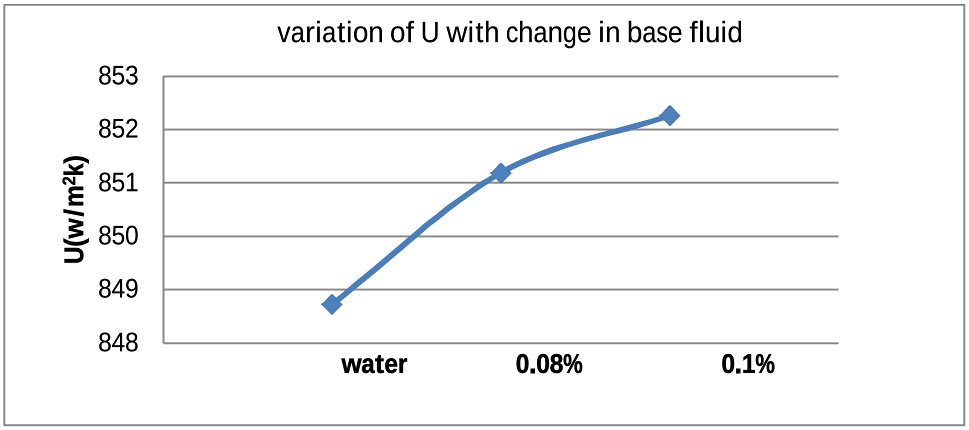


Fig 3.4 Graph determining U value

Variation in the U with different base fluids when taken inlet kwater temperasure at 65˚C

IV. DISCUSSION

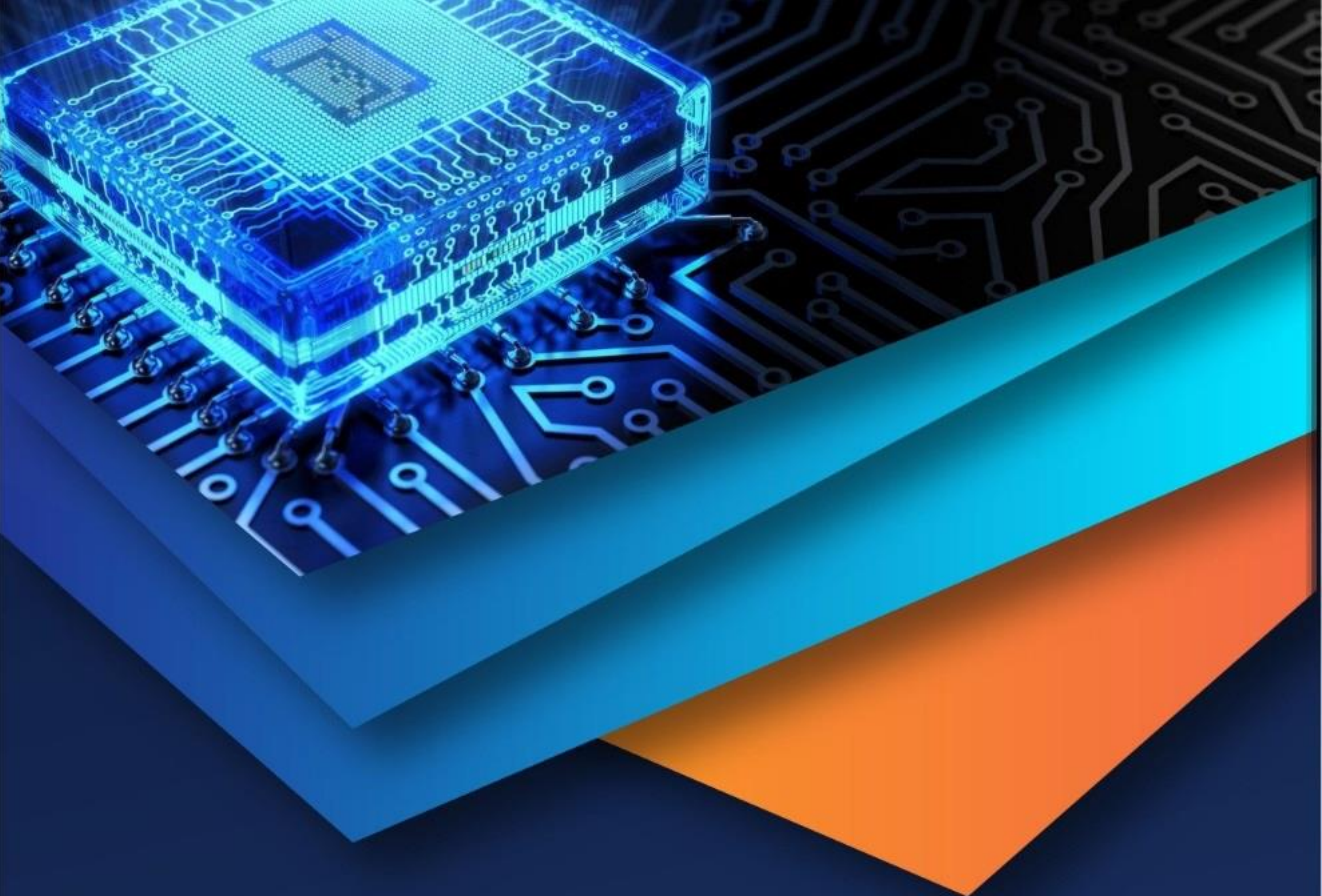
So from the above calculations and graphs we can already conclude the result that using MgO Nano fluid can give us better results in terms of Heat Transfer for a Heat exchanger when compared to normal water**.** And we can also confirm it that this Nano fluid can be better used in industrial proocess such as power plants, oil refineries, natural gas, etc for the better heat transfer, to avoid hot spots and also to compact heat exchangers.

REFERENCES

[1] Ali, H. M. "Heat Transfer Enhancement Of Car Radiator Using Aqua Based Magnesium Oxide Nano Fluids "Thermal science,vol.19,6 (2015) 2039-2048.
[2] Gurbir Singh "Computational Fluid Dynamics Analysis of Shell and Tube Heat Exchanger "JCEET,vol.1,3 (2014) 66-70.
[3] Hiregoudar Yerrennagoudaru, Manjunatha k , S Veerash kumar, Nano Fluids for Heat Exchanger,IJESIT, vol.5, 4 (2016) 82-89.
[4] Jurij Avsec "The Calculation of Thermal Conductivity for Nano fluids Containing Nanoparticles and Carbon Nanotubes", HTJR,vol.35,36(2005) 611-620.
[5] Jaafar Albadr,Satinder Tayal, Heat transfer through heat exchanger using Al2O3 Nano fluid at different concentrations, Case Studies in Thermal Engineering, vol.1,1(2013) 38-44 .
[6] K. Sudhakara Rao, "analysis of flow maldistribution in tubular heat exchangers by fluent", Master thesis,NIT Rourkela,2007.
[7] KHAIRUN HASMADI OTHMAN, "CFD simulation of heat transfer in shell and tube heat exchanger", UMPH, Master Thesis, APRIL 2009.
[8] L.B Mapa , Sana Mazhar,Heat transfer in mini heat exchanger using Nano fluids,ASEE,vol.5,9 (2005).
[9] Mohammad Hemmat Esfe "An experimental study on thermal conductivity of MgO Nanoparticles suspended in a binary mixture of water and ethylene glycol", ICHMT,vol.67(2015) 173-175.
[10] Mohammad Nazififard "Numerical Simulation of Water-Based Alumina Nano fluid in Sub channel Geometry",ijaer,vol.9(2012)
[11] Morton Donald, Thermal design of Heat Exchanger, ACS publications,vol.52,6 (1960) 474-478 .
[12] Periyasamy Mukesh Kumar "Review on Nano fluids theoretical thermal conductivity models", Engineering Journal,vol.19,1 (2015) 67-83.
[13] Qing-Zhong Xue "Model for effective thermal conductivity of Nanofluids"2003 science direct,vol.3,4(2015) 313-317.
[14] Sandeep k patel , Shell and tube Heat Exchanger design, IJAR,vol.4,5 (2014) 91-98
[15] Swapnaneel Sarma, D.H.Das, "CFD Analysis of Shell and Tube Heat Exchangerusing triangular fins for waste heat recovery processes" International Journal(ESTIJ), ISSN: 2250-3498, Vol.2, No.6, December 2012.
[16] Sayantan Mukherjee- "Preparation and Stability of Nano fluids"iosr-jmce,vol.9,2(2013) 63-69.
[17] USMAN UR REHMAN, "Heat Transfer Optimization of Shell and- Tube Heat Exchanger through CFD Studies", AVANCEZ, Master Thesis 2011:09.
[18] Zena K. Kadhim "EFFECT OF (MGO) NANOFLUID ON HEAT TRANSFER CHARACTERISTICS FOR INTEGRAL FINNED TUBE HEAT EXCHANGER",IJMET,vol.7,2 (2016) 11-24.
[19] Barzegarian R, Aloueyan A, Yousefi T. Thermal performance augmentation using water based Al2O3-gamma nanofluid in a horizontal shell and tube heat exchanger under forced circulation. Int Commun Heat Mass Transf. 2017;86:52–9.

Books/Book Chapters

1) P.K.Nag (2013), Engineering Thermodynamics, McGraw Hill Education; 5th edition.
2) R.S.Khurmi & N.Khurmi (March 30, 2005), Steam Tables: With Mollier Diagram in S.I.Units, S Chand & Co Ltd; 8th edition P Kothandaram & S Subramanyam (2014), Heat and Mass Transfer Data Book, New Age International; 8th edition.
3) R.C. Sachdeva (2010), Fundamentals of Engineering Heat and Mass Transfer (SI Units), NEW AGE; 4th edition.
4) R K Rajput (2008), Heat and Mass Transfer SI Unit, S Chand; 5th edition.
5) Versteeg, H.K., Malalasekera, W., An introduction to computational fluid dynamics: the finite volume method.



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ISRA JIF IMPACT FACTOR: 7.129

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