Experimental Investigation on Plate Type Heat Exchanger using Al_2O_3Nanofluid as Coolant

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Abstract-A plate heat exchanger (PHE_x) is a type in which heat transfer take place between two different fluid. this has major advantage over convectional heat exchanger because fluids are exposed over larger surface area. thePHE_x is specially used to transfer heat from medium- and low pressure fluids. the aim of this paper was to examine the ability of nanofuid to increase the performance of PHE_x. the Al_2O_3nanoparticles of about 2% are used in study. A Al_2O_3Nano fluid was tested and compared to base fluid. due to rapid fluid mixing effect strengthens the energy of Nano fluid and temperature profiles are modified. this paper shows the research work on small heat exchanger using Al_2O_3- water base Nano fluid. in this paper we calculate the overall heat transfer due to Nano fluid.

Keywords —PHE_x, Convective heat transfer Coefficient, Al_2O_3, Exchanger Effectiveness.

1. INTRODUCTION

A plate heat exchanger is small exchanger which are specially design for exchange of heat between two different fluid , that are at two different temperatures without mixing of both fluids. In working fluid heat transfer created by disburse of highly thermal conducting solid particles less than 50 nanometers in diameter in medium & low thermal conducting heat fluid such as water, ethylene glycol etc. also the Nano fluid first coined by choi in year 1995 at Argonne National Laboratory. Nano fluid are better in thermal properties over convectional fluid.

[1].Stephen u. S. Choi, hrishikesh e. Patel. Saritkumar das they describe in paper in 2012 that the anomalous thermal fluids, shows surprisingly enhancement in heat transfer.

[2].R. AzizianE.Doroodchi,T.Mckrell,J. Buongiorno, L.W. Hu, According to them the heat transfer takes place in laminar flow due to magnetic flux acting on nanoparticles etc.

[3]. Gaurav Thakur, Gurpreet Singh. they says that if we inject an air bubble in to the fluid it will enhance the heat transfer of nanofluid which will help in fluid characteristics in heat transfer.

[4].Christopher Haslego, Graham Plloey. they designed an plate type heat exchanger which having high thermal conductivity and at low cost.

[5]. Robert Taylor andSylvain Coulombe the described that small particles having big impact on application of Nano fluid when they are mixed in fluids such as water, oils, or glycols etc.

[6].Performance of a plate heat exchanger operated with water-Al2O3 Nano fluidThe main aim of the paper was to experimentally check the ability of Nano fluidsto enhance the performance of PHEx

[7].Ms.Sreejith k., Harikrishnan K., Basil V., DelvinD., Deepak D., Sharath K:- design and Optimization of plate heat exchanger -In this paper they have design the PHE_x for different operating condition. also calculated the overall heat transfer coefficient of plate type heat exchanger and design is optimized so cost of design is reduce.

[8]. Janusz T. Cieslinski, ArturFiuk, WojciechMiciak, BartlomiejSiemienczuk:-Performance of PHE operated with water- Al2O3 Nano fluid- In this paper they examine that the Nano fluid enhance the performance of PHE. A Al2O3 and base fluid Nano fluid tested in 0.1% and 1% by weight. i.e Increase in pressure drop was recorded after each break operation.

[9].JaafarAlbadr, SatinderTayal, MushtaqAlasadi-Heat transfer through heat exchanger using Al2O3 Nano fluid at different concentration: In This article study forced convective heat transfer and flow characteristic consisting of base fluid and different concentration of Nano fluid (0.3%-2%) flowing in exchanger. The 30nm nanoparticle are taken in study. It result that convective heat transfer coefficient of Nano fluidis higher than that of the base fluid at same mass and temperature. increasing volume

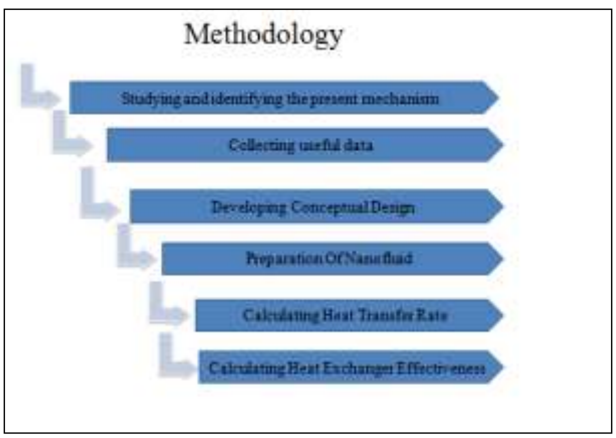
concentration of Al_2O_3 causes increase in viscosity and friction factor

[10]. Vikas Kumar, Arun Kumar Tiwari, Subrata Kumar Tiwari -Implementation of Nano fluid in plate heat exchanger :A review-In This paper elaborates the thermal performance of Nano fluid in PHE base experimental studies. also to focus on investigation on variety of Nano fluid as cooling media in PHE.

1.1 Problem Statement

In recent days conventional fluid used is water which has been widely used to heat exchanger assembly which is having low heat transfer rate so, we use alternative nano fluid is Al_2O_3. Finally, we Design and development in heat exchanger by using nano fluid Al_2O_3 on which recommendations are made and conclusions are drawn based on the improved performance of Nano fluids in a Plate Heat Exchanger.

2. DESIGNING OF EXPERIMENTAION



2.1 EXPRIMENTAL MESUREMENT

Plate type heat exchanger consist pipes and no of thin plates as follow.

Four pipe (copper):- 25mm Outer diameter, and 1mm Wall thickness also it having length 1000mm. Plate used in exchanger are MS of 3mm Thickness and area 150*250mm.

Plate used for support shell are MS of 3mm Thickness and area 200*300mm.

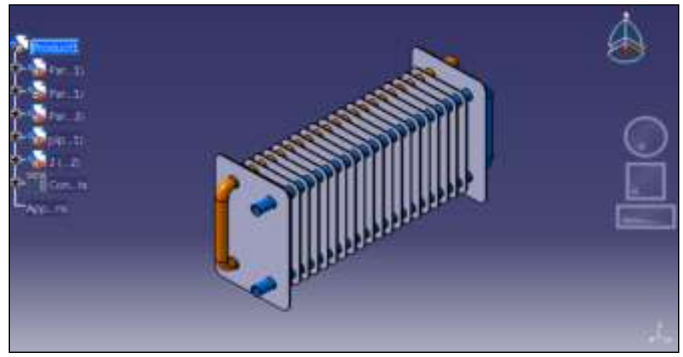
Sensor used are K type thermocouple.

Heater used in having 2000w power.

Motor used in having 18 feet height flow and 1500 lph flow.

Power used AC supply.

2.2 CAD MODEL



2.3 .ACTUAL SETUP

2.4 ROCEDURE

[1]. Ensure all the connection of hose are leak proof.

[2].Open the Exchanger and hot water tank pour clean water in the and nanofluid in the ratio 80:20

[3]. Take Al2O3 nano fluid, and pour solution in Exchanger cooling tank.

[4]. Close the Exchanger and connect the pump and heater to external power supply.

[5]. Open knob of rotameterupto 10 lpm and after pump and heater for temperature 60^{o}c.

[6]. Adjust the flow rate to 10 lpm and take reading for each flow rate after every 2 min (upto 8 lpm).

[7]. Also measure outlet temperature of PHE.

2.5 WORKING

The water is heated by heater and circulated by pump into setup. so there is gradual increase in temperature sensor. there is heat transfer between the system and surrounding by natural convection when pump is switched on, there is forced convection between system and surrounding. there is increase in heat transfer rate. when coolant flows through it fins conduct the heat from tube and transfer it to the fluid flowing through exchanger. tubes have a plate type of fin inserted into them called plate. By creating turbulent flow inside the tube which mixes the all fluid together, due to which temperature of fluid becomes high which transfer heat. and all of fluid inside the is used effectively. Adding Ethylene glycol with water further enhance heat transfer. Al2O3 added have better heat transfer rate than Ethylene glycol, the nano particle used in it with proper suspension of nano particles in base fluid. now the fluid inlet and outlet temperature, are observed and calculation are carried out.

3.RESULT AND DISCUSSION

Materials	density (Kg/m^3)	Specific Heat (J/kg-k)	Thermal conductivity (W/m.K)	Viscosity (Pa.s)
PureWater	1008	4187	0.58	0.0019
Al_2O_3	1059.49	387.46	1.4	

Thermal properties of water and Al_2O_3nanofluid

In order to study Plate type heat exchanger, the nanopartical increase the thermo physical properties of the base fluid. By using nanofluid we will increase the heat transfer characteristics of the exchanger. Nanofluid gives the good result than water. Also the increases or decreases of the mass flow rate, is affect on heat transfer rate.

3.1 RESULT TABLE

ṁ lpm	T min	ΔT_w ºC	ΔT_{nf} ºC	Q_{avg} w W	Q_{avg}nf	$\mathcal{E}_w$	$\mathcal{E}_{nf}$
10	2	13.7	14.9	6999.51	7767.22	0.257	0.362
10	4	13.6	14.9	7099.93	7700.23	0.271	0.355
9	6	15.1	16.7	7284.1	8055.07	0.289	0.393
9	8	14.9	16.9	7472.49	8114.19	0.317	0.393
8	10	15.5	17.9	7413.80	8401.34	0.349	0.466
8	12	15.6	17.5	7413.81	8263.55	0.346	0.463

3.2 ANALYSIS OF HEAT EXCHANGER

The analysis of the heat exchanger as following:

1. Hot fluid heat transfer rate $Q_h = m_h \times C_{ph} \times (Th_i - Th_o)$
2. Cold fluid heat transfer rate $Q_c = m_c \times C_{pc} \times (T_{Co} - T_{Ci})$

Where (Th_i, Tho) is the inlet and outlet temperature of the hot fluid. And (T_{Ci} ,T_{Co}) is the inlet and outlet temperature of the cold fluid. $m_h$and m_C is the mass flow rate of hot and cold fluid.

$$Q_{avg} = \frac{(Qh + Qc)}{2}$$

3. Effectiveness of the Heat Exchanger

$$\mathcal{E} = \frac{\dot{m}hCh\ (Thi - Tho)}{\dot{m}cCc\ (Thi - Tci)}$$

4. Density of nanofluid calculated

$$\rho_{nf} = (1 - \varphi) \times \rho_{bf} + \varphi \rho_p$$

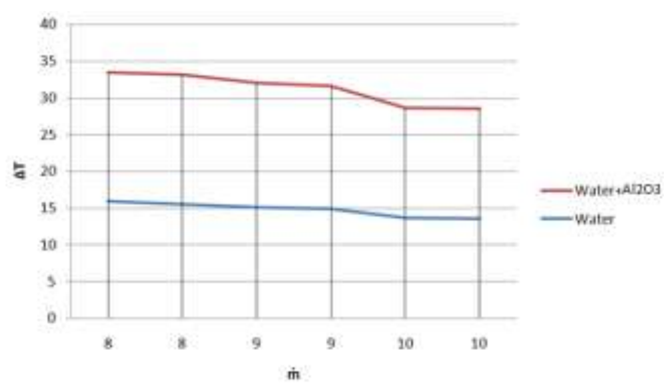
5. Specific heat of the nanofluid

$$C_{pnf} = \frac{\varphi \times C_{pnp} + (1-\varphi) \times \rho_{bf} \times C_{pbf}}{\rho_{nf}}$$

Where ρ_{nf},C_{pnf} is the density and specific heat of the nanofluid respectively. Φ is the weight concentration of the of the nanopartical in volume of the base fluid.C_{pnp} and C_{pbf} is the specific heat of the nanopartical and base fluid respectively.

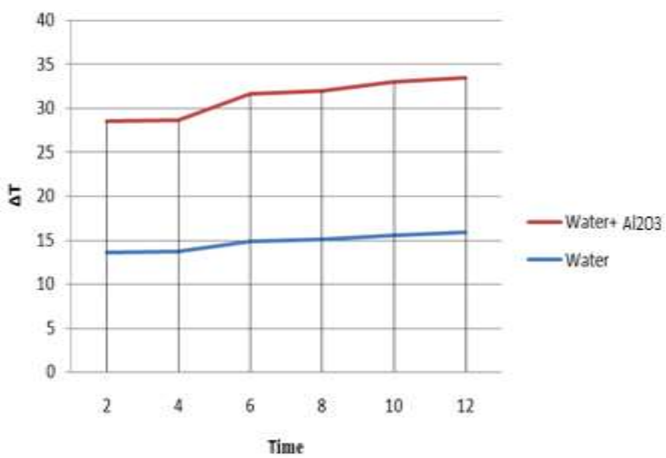
3.3 GRAPHICAL REPRESENTATION

1. Mass flow rate (lpm) vs. Temperature difference



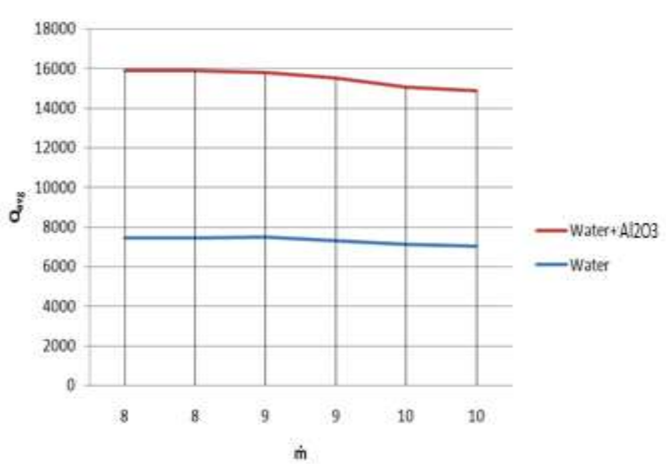
From the above graph we concluded that:
With increases the mass flow rate, the temperature difference between inlet and outlet of the working fluid is decreases. In the graph 1 we see that nanofluid conduct better heat.

2. Time (min) vs. Temperature difference (ºC)



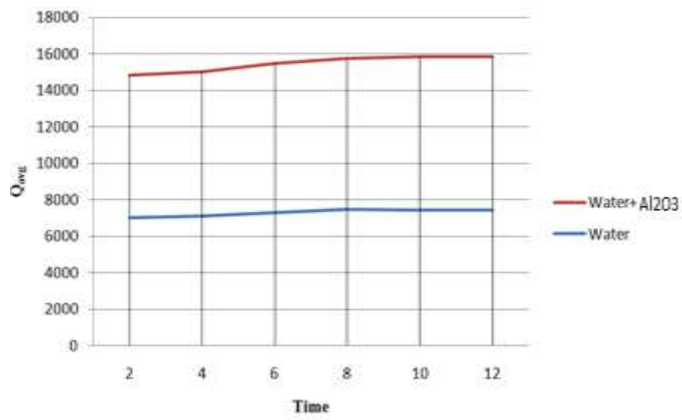
From the above graph we concluded that:
As we increases the time by every 2 min there is increases the temperature diffreance between inlet and outlet of the fluid. That means if we increase the time ,nanopartical get more heat from the hot fluid. So as we increase the time temperature difference in both fluids is increases.

3. Mass flow rate (lpm) vs. Average heat transfer rate(W)



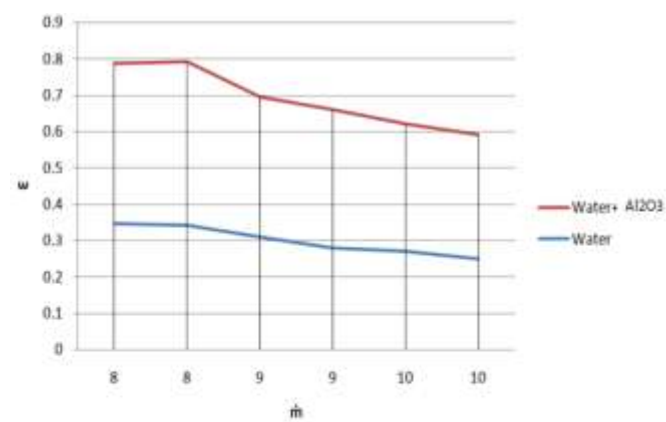
From the above graph we concluded that: From graph we see as we decreases the mass flow rate, there is average heat transfer rate of the nanofluid increases. In the graph shows average heat transfer of the nanofluid is greater than water.

4. Time (min) Vs. Average heat transfer rate (W)



From the above graph we concluded that: With increases the time the average heat transfer rate also increases. Nanofluid gives better heat transfer than water.

5. Mass flow rate (lpm)vs. Effectiveness



From the above graph we concluded that:
If we decreases the mass flow rate there is increases the Effectiveness of the heat Exchanger. Effectiveness is the ratio of actual to the maximum possible heat transfer rate from hot fluid to cold fluid.

4. CONCLUSION

It is concluded that addition of nanoparticles resulted increase in heat transfer rate of PHE, than water tested in it. nanoparticles volume fraction leading to the improvement in thermophysical properties. its seen in experiment that the effectiveness of nanofluid depends on not only thermophyical properties also depend on flow behavior (i.e. laminar or turbulent) of fluid. effectiveness decreases with increase in Reynolds number. so it is seen that nanofluid is having more effect on heat transfer rate.

5.REFERENCES

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