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SCOPE DATABASE INDEXED

EXPERIMENTAL & PERFORMANCE ANALYSIS OF A CORRUGATED PLATE HEAT EXCHANGER USING AL_20_3 NANO FLUIDS

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ABSTRACT

In the experimental work are studies carried out to the corrugated PHE in a parallel flow and counter flow heat exchanger arrangement The heat transfer rate maximum increases with increase of volume weight percentage of nano particle in the cold fluid, the maximum heat transfer rate increases. in parallel flow and counter flow arrangement. It is also observed that with rise in inlet hot water temperature the heat flow is reduced in heat loss in counter flow. Hot fluid was made to flow in the central channel at different inlet temperature ranging from 40°C to 70°C to get cooled by the cold fluid in the upper and the lower channels. The required pump power increased with increased in nano fluid weight concentration for better heat transfer rate in effectiveness in lower consumption of power or LMTD reduced in lower rate of 0.5 - 1LPM. The experimental investigation it is observed that the average heat transfer non-dimensional exergy loss (E/Qmax) addition of Al_2O_3 nano particle in the cold fluid improve the exergy and effectiveness and saving the energy of the heat exchanger by 36%. Exergy analysis is also conducted. Exergy loss is reduced by mixing aluminium oxide nano particle in the cold fluid. The exergy analysis was conducted parallel flow and counter flow arrangement. Al_2O_3 nanoparticles were added in the cold fluid in different proportions to enhance the system performance. General relationship between energy effectiveness and exergy efficiency has been established as well. The result shows that the exergetic efficiency increases with the Reynolds number, hot and cold water inlet temperatures.

Keywords: Corrugated Phe, Exergy Losses, Effectiveness, Mass Flow Rate, Enhancement Heat Flow.

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Nomenclature E= exergy loss (W), m= mass flow rate, A= area of cross section, i= inlet h= heat transfer coefficient, P= pressure, f= friction factor, L=length (m), R= capacity ratio, Q= heat transfer rate(W). h =convective heat transfer coefficient, (Wm^{-2} K^{-1}), L= plate length, (mm), N number of corrugated plates, Nu = Nusselt number, P =pressure, Pr= Prandtl number, Q= heat transfer rate, (W), Re=Reynolds number, t=corrugation pitch mm, U=overall heat transfer coefficient, (Wm^{-2} K^{-1})·V=volume flow rate, (L min^{-1})W =plant width, (mm).

1. INTRODUCTION

Industrial demands for high performance heat exchanger devices are increasing rapidly day by day to get substantial reduction in energy consumption. The plate heat exchangers (PHEs) are compact and efficient, widely used in many applications (heat recovery, cooling, HVAC, breweries, dairy, food processing, offshore oil, pharmaceuticals, chemical, pulp and paper production, power generation, refrigeration, etc.) because of their high thermal efficiency, flexibility and ease of sanitation. The corrugated shaped patterns of the individual plate geometries are one of the many suitable techniques to enhance the heat transfer in heat exchangers. When fluid flows in a corrugated channel, the flow becomes disturbed due to growing recirculation regions near the corrugated wall, which enhances the turbulence resulting to achieve the highest possible heat transfer coefficient with minimum pressure drop. These advantages make the PHE more environmental friendly; however, increases of emission and running cost due to high leakage possibility, pressure drop are some environmental disadvantages. Enormous theoretical and experimental research works on heat transfer, fouling and fluid flow aspects of PHE with various geometries and heat transfer fluids for various potential applications have been performed within last few decades (Abu-Khader, 2012). In the recent decades, the combination of the first and second law of thermodynamics has aroused wide spread interest, which includes the entropy and exergy (Bejan, 1982; Hesselgreaves, 2000). On the basis of the concept of entropy, several heat exchanger performance criteria (entropy generation, exergy loss or irreversibility and second law or exergetic efficiency) have been used for heat exchanger design, performance evaluation and optimisation (Abdel- Moneim and Ali, 2007; Akpinar and Bicer, 2005; Sarkar et al. 2009; Yilmaz et al. 2001; Naphon, 2011). A theoretical study on irreversibility of a single-pass PHE in the presence of fluid dispersion has been performed for cryogenic application (Das and Roetzel, 1995, 1998). Wu et al. (2010) derived the expression of exergy transfer units number for heat exchanger. However, derivation of energy–exergy relationship is scarce in open literature. Durmu's et al. (2009) experimentally investigated the effects of surface geometries of three different types of PHEs, namely flat PHE, corrugated PHE and asterisk PHE on heat transfer, friction factor and exergy loss. Pandey and Nema (2011) also experimentally investigated the exergy loss reduction in corrugated PHE. However, none of these papers presented the exergetic efficiency (which may give the deviation from ideal one and possibility of improvement) of the PHE considering heat loss. The main objective of the present paper is to study the exergetic performance of corrugated PHE using water in steady-state operation with considering the heat transfer, viscous dissipation due to flow inside the test section and the heat loss outside the test section. The present experimental investigations were carried out to evaluate heat transfer and pressure drop characteristics, effectiveness, exergy loss, dimensionless exergy loss and exergetic efficiency of PHE under different volume flow rates and operating temperatures. Theoretical and experimental relationships between various energetic and exergetic performance parameters of PHE have been derived and discussed as well.

(The PHE are combination of a pack of metal plate in GI with corrugation, in each plate design with a port hole with at their needs to facility the passes of the fluids medium between two or more copper pipe in heat transfer takes place; Heat exchangers are widely used in various industries like automobile radiator dairy form industries and medical equipment also, one of the most commonly used process equipment in the industry and research. In heat exchanger is widely used in involving heating or cooling of fluid stream concentrate and stream of and evaporation or condensation of single or multiple stream component. Rai et al. (2016), The work of a heat exchanger is various used into exchange energy from the body at higher temperature to the body at lower temperature external sources of reservoir lower temperature fluid in supply to resist heat for equipment. Kumar and Rai et al. (2014) The study demonstrates the potential of Al_2O_3 nanoparticles to enhance the performance of a corrugated plate heat exchanger in a parallel flow arrangement. By introducing these nano particles into the cold fluid, both the effectiveness of the heat exchanger and the maximum heat transfer rate are improved. Furthermore, in the exergy loss is significantly reduced, resulting in a more efficient heat exchange process. The present experimental investigations were carried out to evaluate heat transfer and pressure drop characteristics, effectiveness, exergy loss, dimensionless exergy loss and exergetic efficiency of PHE under different volume flow rates and operating temperatures. Theoretical and experimental relationships between various energetic and exergetic performance parameters of PHE have been derived and discussed as well. These findings suggest that using nano particles in heat exchangers could lead to substantial energy savings and reduced costs in various applications. Now a days in many researchers are used in this equipment for saving energy and reduced the cost, and setup are established for industries for minimal normal cost.

2.DESIGN AND PERFORMANCE PARAMETERS OF HEAT EXCHANGER

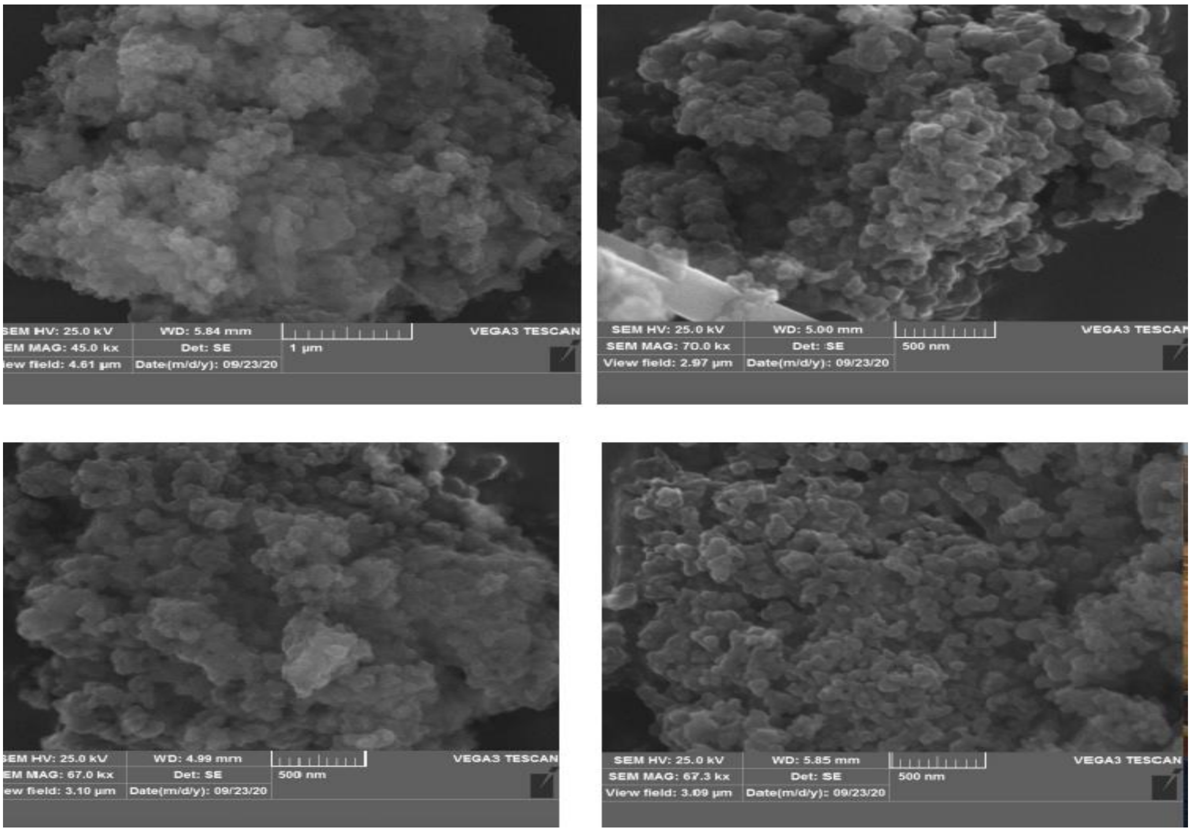
In Design performance parameter will be applicable in the all-sustainable industrial application such that the resources in set up paragraph of experimental set up in medical application. The application should be defined parameter are adjustable in variable applicable parameters, the turning of mechanical parts is design in gas plate and fabricated and weldability in solderingand advanced technic should be considered and applicable for the turbulence effect and reduced in parallel flow and counter flow arrangement and increased thermal conductivity.

3. ABOUT ALUMINIUM OXIDE (AL_2O_3) NANO PARTICLE

Density nano particle	0.1-0.3 gm/cm^3
From purity	99.98%
molecular weight	102.96 gm/mol
Size particle	30-49.99 nm
Melting point	2055^{o}C
CAS no	1335-23-.99
Morphology	Near spherical
Colour	White

Picture (a) Al_2O_3nano particle in open

Picture (b) Al_2O_3nano particle in packed



Picture:1 Full SEM (scanning electron microscope) Al_2O_3nano particle

4. THERMOPHYSICAL PROPERTIES OF ALUMINIUM OXIDE WATER (AL_2O_3) FLUID

wt in gm	Ψv	Cp(J/Kg-K)	μ (mPa. s)	ρ(kg/m3)	K(W/m.K)	Re	Pr	Nu
water	Nil	4180	0.789	995.7	0.615	29543.6	5362.634	9529.756098
70	0.0358	4062	0.9749272	996.5	0.651	23928.59	6083.186	9002.764977
140	0.0716	4056	1.071648	997.1	0.657	21782.04	6615.836	8920.547945
210	0.1074	4050	1.1823547	997.6	0.668	19752.43	7168.468	8773.652695
280	0.1432	4044	1.3097589	998.8	0.669	17852.5	7917.287	8760.538117
350	0.179	4038	1.4572435	999.7	0.65	16060.15	9052.845	9016.615385

4. MOTIVATION OF THE PRESENT WORK

Plate type heat exchanger are widely used due to its compactness and better heat exchanger capacity, exchangeability. The Heat transfer rate further increased by using different shape ribs, inserts, extended surface. So corrugated plate heat exchanger sinusoidal wavy plate is gating popularity due to increased surface are or heat transfer rate. Recent trends of use of the nano fluids in a heat exchanger has further attracted the researchers use of nano fluids with enhanced thermal properties by use of high thermal conductivity nano particles popularised further researchers on the heat exchangers with nano fluids. Hybrid nano fluids enhancement of heat transfer use hybrid nano fluids. Is the subject of growing importance in various industrial application due to low to moderate and high thermal conductivity.

5. EXPERIMENT SETUP

The picture of experimental set up are fabricated in 22-gauge GI SHEET. In this experiment the two different cases are applicable in the form of arrangement of set up parallel flow and counter flow of the experiment includes the water loop of the measurement system comprises a water tank are containing heater and flow rate are measure thermally insulated material like wood dust and hot fluid are flow in central channel and cold fluid are flow in upper and lower channel, and temperature are measure in zeal thermometer.

Picture 1: full Photographs with experimental setup

5.1. Specifications of the experimental setup.

Set up Length =100 cm

Set up Width = 10 cm

the gap between corrugated plates = 5 cm and angle of the plate is = 45°

the plate material is GI of 22 gauges.

6. EXPERIMENTAL PROCEDURE

Experimental procedure Hot and cold water are two different cases in inlet and outlet temperature of water provided in the different channel first in inlet hot water temperature and outlet. The Cold-water loop compromise a water tank is considerable 40˚ to 70˚C inlet temperature of hot water in parallel and counter flow arrangement. varying at 0.50 to 1 LPM and 0.50 to 2 LPM. The flow rate is measure by noting done in time for fixed and different volume of the fluid.

In the hot and cold channel loop in a measurement system, thermocouple device is used for temperature measurement flow through the central corrugated channel to maintain the channel surfaces at approximately constant temperature the hot water loop comprises in a water tank, and heater and water tank with pump. In the whole system are thermally insulated with wood dust particle, and water flow are in measure lpm unit base.

7. NUMERICAL METHODOLOGY

In the present experiment, the properties of Al_2O_3nano particle dispersed in the water fluid was measured are given below.

The experimental data was used to calculate the heat transfer rate,

Q = mhCh (Thi - Tho)

Each channel has equal flow area and wetted perimeter given by, Ao = H.W, and p = 2(W+H)

Specific Heat capacity Ch = mhcph.

Cc = mccpc

Logarithmic mean temperature difference.

LMTD= [(T ho –Tci) – (T hi - Tco)]] / ln [(T ho – Tci)/(T hi -Tco)]

Effectiveness of heat exchanger,

Ɛ = [Cc (T co –Tci)]/ [C minln (T hi – Tci)].

The energy changes for the two fluids are obtained as given below, For hot fluid (i.e., water),

Eh = Te [Chln(Tho/Thi)]

And for cold fluid

Ec = Te [Cc ln (T co /T ci)

Exergy loss for steady state open system can be found as a sum of individual fluid exergy,

E = E h+E c.

8. RESULT AND DISCUSSION

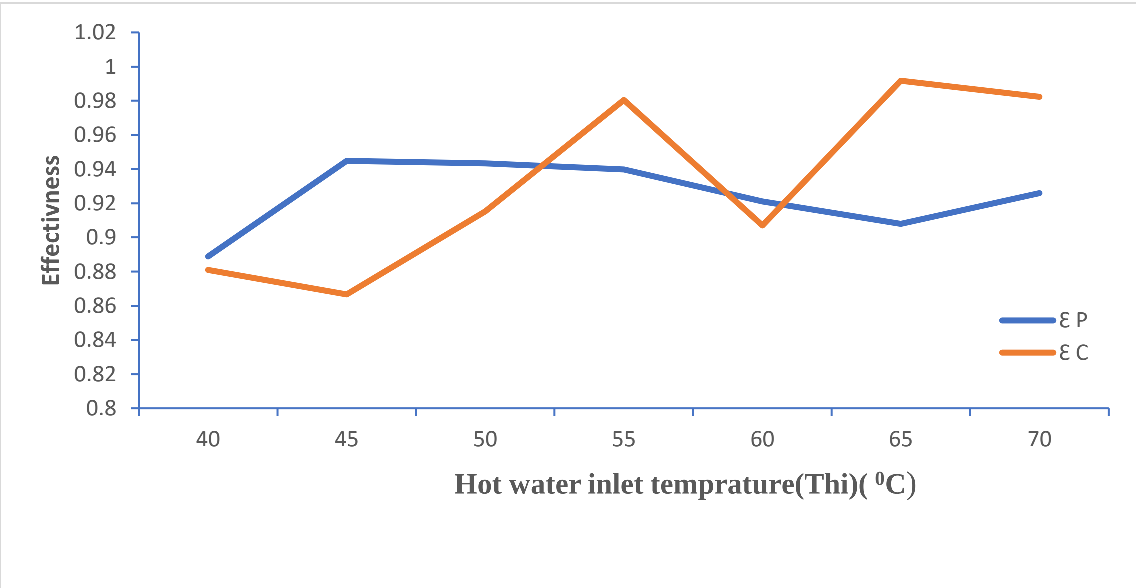


Figure 1. Effectiveness v/s Temperature of hot water inlet

Effectiveness will rise maximum in 50^0C - 55^0C in figure 1 the effectiveness will increase in increase temperature. The exergy will be increased in different inlet temperature, for parallel and counter flow arrangement.

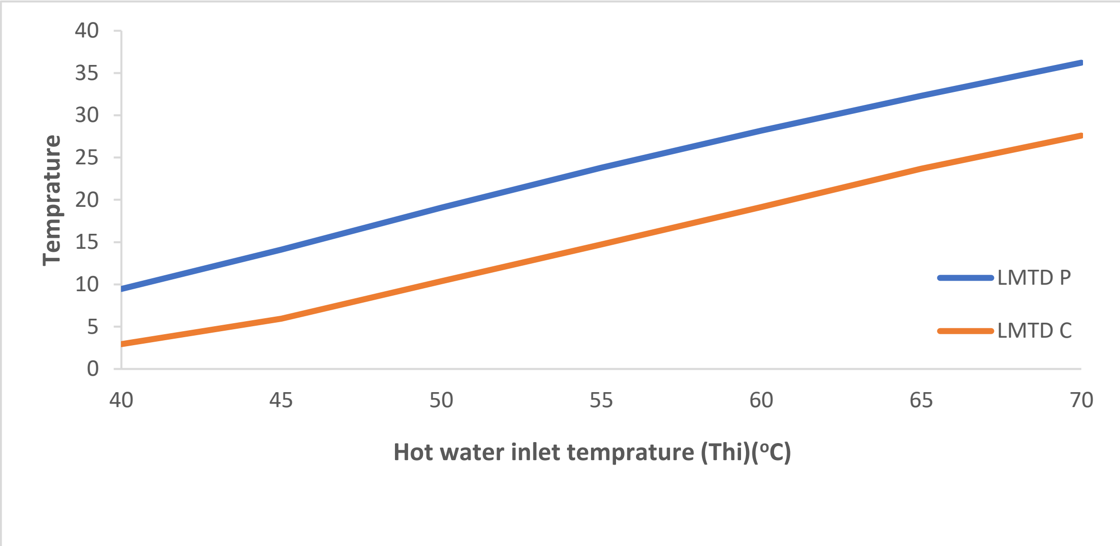


Figure 2. Mass flow rate 0.5LPM v/s 0.5% volume concentration

mass flow rate in 0.5 LPM the at different inlet temperature in varies in 55^c C to 70^oc for minimal amount of heat lose and better heat transfer rates in lower temperature difference.

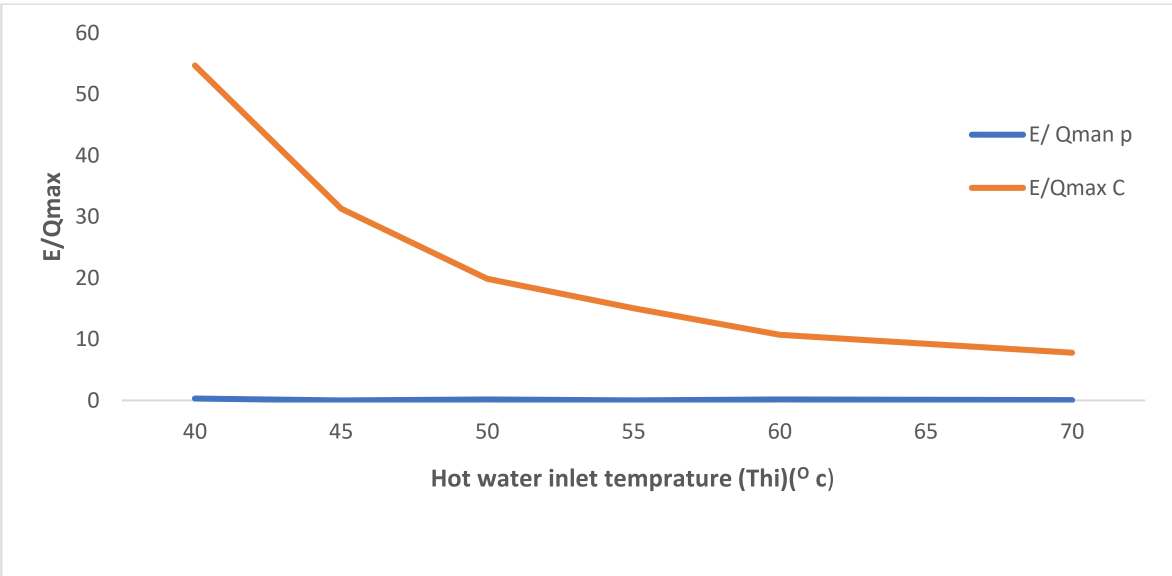


Figure 3. E/Qmax v/s hot water inlet temp

In Fig 3. The variation of non-dimension exergy loss E/Qmax will be increases in parallel flow arrangement., with little amount fluid volume concentration are increase. And variation of effectiveness and temperature difference will be seen in counter flow arrangement. And E/Qmax will increased seen in maximum in 60^0C temperature.

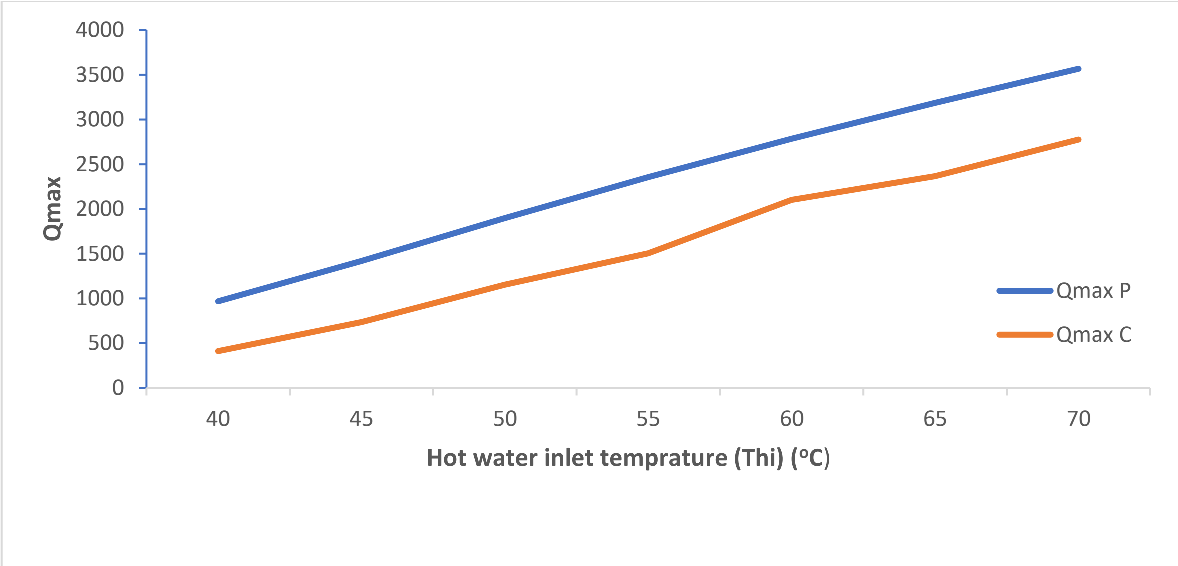


Figure 4. Qmax v/s hot water inlet temperature

In this figure mass flow rate of 0.5 lpm at different volume concentration the heat and dimensional exergy are exact same of the different mass flow rate will be increased in 40^{0} - 70^{0}C and Qmax will be change little and exergy will be no change in volume const concentration.

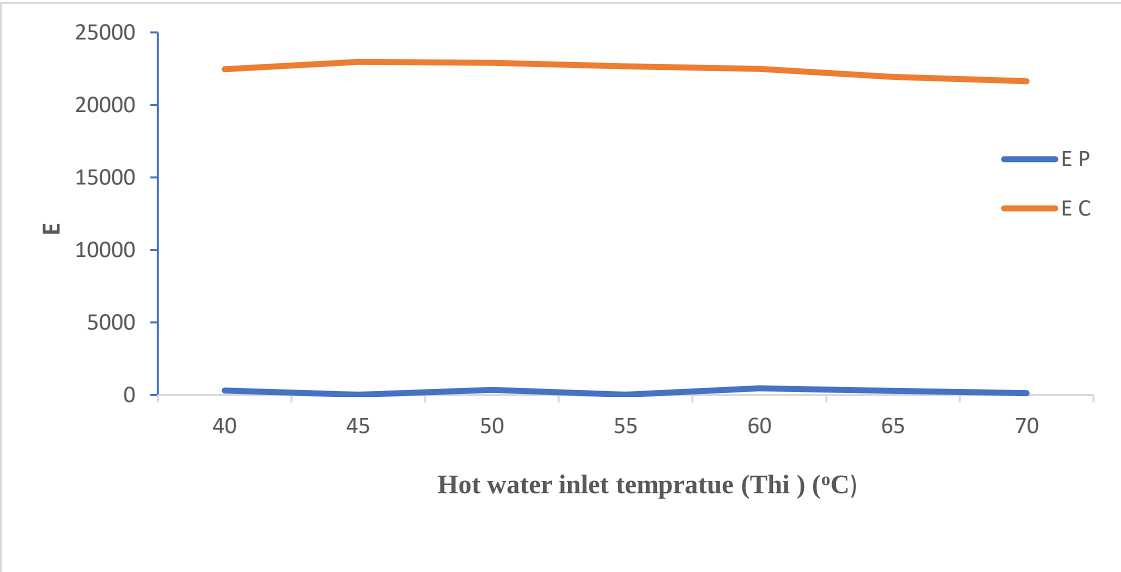


Figure 5. E v/s hot water inlet temperature (Thi) (ºC)

In. Fig 5 volume 0.5 LPM in 0.5 weight % of Al_2O_3 in the water increase in effectiveness rate 89% to 93% but exergy loss to reduced 24%. And effectiveness will be ideal condition in volume concentration.

SUMMARY AND CONCLUSIONS

The experimental investigation is concluding the aluminum oxide nano fluids are having better heat transfer rate as compare to base fluids or coolant. The volume concentration of 0.35, the heat transfer rate enhances 36% compare with base fluids from 40^{O}C to 70^{O}C.The performance of a heat exchanger in following conclusions are drawn from the present work.

1. The Effect of temp Th_1 from 40^OC to 70^OC is more significant on Th_2 when plain cold water is added.
2. As the volume percentage of Al_2O_3 increases in cold water at different inlet temperature of hot fluid (40^0C to 70^0C).
3. In the effectiveness are more significant compare to parallel to counter flow arrangement.
4. In exergy loss are found in 1 lpm.
5. It observed that LMTD of the system in 83 % higher in parallel flow arrangement to counter flow arrangement.
6. The temperature range in 40^0C- 70^0C. in better performance corrugated PHE in 55^0C-60^0 C.
7. Mixing of nano particle in cold fluid increase heat transfer rate capability.
8. Exergy loss increases with increases inlet cold water temperature for the same in hot water temperature.
9. In the variation of maximum heat transfer rate in corrugated PHE in parallel and counter flow arrangement.
10. The addition of nano particle in the cold fluid reduced the non dimensional flow exergy losses. With increase in volume percentage of nano particle.

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