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Performance Analysis of Shell and Tube Heat Exchanger using Nano Fluid

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***Abstract*—Nanofluids are suspensions of nanoparticles in fluids that show significant enhancement of their properties at modest nanoparticle concentrations. Nano fluids are found to be having the best thermal transport property in the recent years many investigations are took place to improve the thermal efficiency by using the nano fluids which might become the revolutionary solutions to the heat transfer problems and the nano fluid can in future over take the places of the conventional fluids.**

The proposed analysis is carried out whether the method can help in the extraction of heat and to That to what extent we can use this for the better results in the thermal efficiency. The analysis is carried out by using B L method and kern method and graphs are plotted, compared with water to water results.

Keywords—Nano Fluids, Heat Exchanger, Thermal Efficiency

I. INTRODUCTION

The natural laws of physics always allow the driving energy in a system to flow until equilibrium is reached. Heat leaves the warmer body or the hottest fluid, as long as there is a temperature difference, and will be transferred to the cold medium. A heat exchanger follows this principle in its endeavour to reach equalisation. With a plate type heat exchanger, the heat penetrates the surface, which separates the hot medium from the cold one very easily. It is therefore possible to heat or cool fluids or gases which have minimal energy levels. The theory of heat transfer from one media to another, or from one fluid to another, is determined by several basic rules.

- Heat will always be transferred from a hot medium to a cold medium.
- There must always be a temperature difference between the media.
- The heat lost by the hot medium is equal to the amount of heat gained by the cold medium, except for losses to the surroundings.

Types of heat exchanger:

1. Double-pipe exchanger: the simplest type, used for cooling and heating.
2. Shell and tube heat exchanger
3. Plate heat exchanger
4. Plate and shell heat exchanger
5. Rotating wheel heat exchanger
6. Plate fin heat exchanger
7. Pillow plate heat exchanger
8. Fluid heat exchangers
9. Spiral heat exchangers.
10. Air cooled: coolers and condensers
11. Direct contact: cooling and quenching
12. Agitated vessels

II. NANO FLUIDS PREPARATION

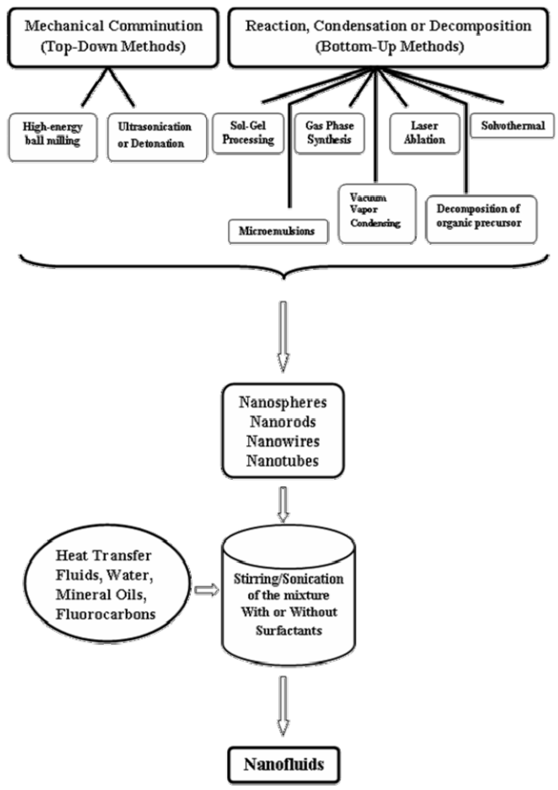

Fig 1. Two step process for Nano fluid Preparation

III. SHELL AND TUBE HEAT EXCHANGER

Shell and tube heat exchanger consisting of a calming section, test section, rot meters, overhead water tank for supplying cold water & a constant temperature bath for supplying hot water with in-built heater, pump & the control system. The test section is a smooth stainless tube with dimensions of 800mm length, Inner diameter of tube- 16mm ID, and Outer diameter of tube-19mm OD. These tubes are arranged in triangular pitch in the shell. Two calibrated rot meters, with the flow ranges,

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are used to measure the flow of cold water. The water, at room temperature is drawn from an overhead tank using gravity flow. Similarly a rot meter is provided to control the flow rate of hot water from the inlet hot water tank. Four thermo-couples are used measure the inlet & outlet temperature of hot water & cold water (T1 –T4) through a multipoint digital temperature indicator. Sensors are inserted to measure the mass flow rate in shell and as well tubes sides.

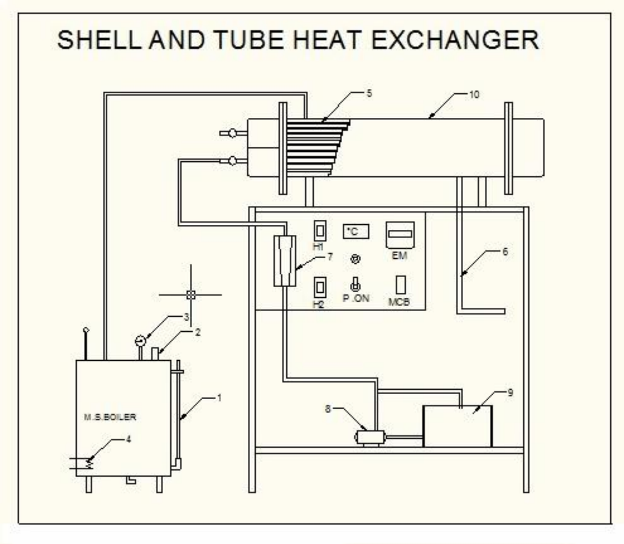

Fig 2. Line Diagram of Shell And Tube Heat Exchanger.

IV. EXPERIMENTAL PROCEDURE AND CALCULATIONS

- Water is collected upto some volume in the tanks provided in the experimental set up of shell and tube heat exchanger.
- All the rotameters & RTD are calibrated.
- Shell and tube heat exchanger set up is made ON and heater provided is connected to the red water tank.
- Temperature is taken into consideration as water is started to heat.
- Pumps of shell side and tube side are started and flow takes place. Hot water at about 60°C is allowed to pass through the shell side of heat exchanger for water to water method.
- In the red tank side nano fluid is introduced for water-nano fluid method and passed to the shell side of the heat exchanger
- Cold water is now allowed to pass through the tube side of heat exchanger in counter current direction at a desired flow rate.
- The water inlet and outlet temperatures for both hot water & cold water (T1-T4) are recorded only after temperature of both the fluids attains a constant value.
- The procedure was repeated for different cold water flow rates
- Temperatures are noted through the display. Temperatures for shell inlet and out let and tube side inlet and outlet are calibrated using thermocouples connected at every inlets and outlets.
- Minimum three readings are taken for every flow and average is considered.
- The values are noted down through the computer connected to the experimental set up.
- Values are logged in for every reading using the software interface.
- Graphs are generated for every flow and temperatures in the excel sheets.
- Properties of fluids used is to be enter if different fluid is used other than water as water's properties are already been induced in the software provided.
- But for nano fluid the thermal conductivity value is separately fed into the software
- After completion of logging many readings, the log sheet of results is generated which is to be saved for calibration
- Standardization of the set-up:Before starting the experimental study on friction & heat transfer in heat exchanger, standardization of the experimental setup is done by obtaining the friction factor & heat transfer results for the smooth tube & comparing them with the standard equations available.
- Pressure drop is measured for each flow rate with the help log sheet.
- Over all heat transfer rate is measured.

  Discuss your results, by
- Commenting on the results and possible reasons for discrepancies,
- Reporting on the possible sources of errors in the experiment, and
- Analyzing the assumptions made during the experiment and their effects on the results in detail.

V. KERN'S DESIGN PROCEDURE

Shell and tube heat exchanger is designed by trial and error calculations. The procedure for calculating the shell-side heat-transfer coefficient and pressure drop for a single shell pass exchanger is given below The main steps of design following the Kern method are summarized as follows:

STEP 1: Calculating the area of cross flow As, for hypothetical row of tubes at the shell Equator, given by

As = {(Pt – Do)*Ds*Lb} /Pt

STEP 2: Calculate shell side mass velocity Gs and linear velocity Us.

Gs = ms / As or Us = Gs / ρs

STEP 3: Calculate the shell side equivalent diameter De.

For square pitch:

$De = [4*(Pt^2 – \{(\pi/4)* Do^2\}] / (\pi* Do)$

For triangular pitch:

$De = [4*\{(Pt^2*\sqrt{3})/4\} – \{(\pi* Do^2)/8\}] / [(\pi*Do)/2]$

STEP 4: Calculate shell side Reynolds number Res.

Res = (Gs* De) / μs Or Res = (Us* De* ρs) / μs

STEP 5: Calculate shell side Prandtl number Prs.

Prs = (Cps*μs) / Ks

STEP 6: Calculate the shell side heat transfer coefficient hs

hs = 0.36*(Ks / De)* (Re^0.55)*(Pr^0.33)*{(μs / μw)^0.14}

Note: The value of (μs / μw) ^0.14 = 1, for water.

CALCULATION OF SHELL SIDE PRESSURE DROP

STEP 7: Calculate the number of baffles on shell side Nb.

Nb = {Ls / (Lb + tb)} – 1

STEP 8: Calculate the friction factor f.

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f = exp {0.576 – (0.19*Ln Res)}

STEP 9: Calculate the shell side pressure drop ΔPs.

$\Delta Ps = [4 * f * Gs^2 * Ds * (Nb+1)] / [2 * \rho * De * \times \{(\mu s / \mu w)^{0.14}\}]$

Or

$\Delta Ps = [f * Gs^2 * Ds * (Nb+1)] / [2 * \rho s * De * \{(\mu s / \mu w)^{0.14}\}]$

CALCULATION OF TUBE SIDE HEAT TRANSFER COEFFICIENT

STEP 1: Calculate the tube side cross flow section area At.

$At = \{(\pi * Di^2) / 4\} * (Nt / 2)$

STEP 2: Calculate the tube side mass velocity Gt and linear velocity Ut.

Gt = mt / At Or Ut = Gt / ρt

STEP 3: Calculate the tube side Reynolds number Ret.

Res = (Gt* Di) / μt Or Ret = (Ut* Di* ρt) / μt

STEP 4: Calculate the tube side Prandtl number Prt.

Prt = (Cpt*μt) / Kt

STEP 5: Calculate the friction factor f.

f = {(1.58*Ln Ret) – 3.28} ^ (-2)

STEP 6: Calculate the tube side Nusselt number Nut.

$Nut = \{(f/2)*(Ret - 1000)* Prt\} / \{1 + (12.7*\sqrt{(f/2)}*(Prt^{(2/3)}) - 1)\}$

STEP 7: Calculate the tube side heat transfer coefficient hi.

hi = (Nut * Kt) / Di

CALCULATION OF TUBE SIDE PRESSURE DROP

STEP 8: Calculate the pressure drop on the tube side ΔPt.

$\Delta Pt = [\{(4 * f * Lt * np) / Di\} + (4 * np)] * [(\rho t * Ut^2) / 2$

Table2: Heat Exchanger data at the shell side

S.No	Quantity	Symbol	Value
1	Shell side fluid		Water
2	Shell side Mass flow rate(Kg/sec)	Mt	0.060
3	Shell ID(m)	Ds	0.2
4	Shell length(m)	Ls	0.800
5	Tube pitch(m)	Pt	0.03
6	No. of passes	n	1
7	Baffle cut(m)	Lb	0.2
8	No. of baffles	N	4

Table3: Heat Exchanger data at the tube side

Sl.no	Quantity	Symbol	Value
1	Tube side fluid		Water+ nano fluids
2	Tube side Mass flow rate (Kg/sec)	Mt	0.060
3	Tube OD (m)	Do	0.019
4	Tube ID(m)	Di	0.016
5	Tube thickness(m)	Tp	0.0162
6	Number of Tubes	N	18
7	Tube length(m)	Lt	0.825

Table 4: Fluid Properties of Water

S. no	Property	Unit	Cold water shell side	Hot water tube side	Silver Nano fluid	Silicon Dioxide Nano Fluid
1	Specific Heat (Cp)	KJ/kg. K	4.187	4.187	4.485	4.278
2	Thermal conductivity (k)	W/m. K	0.00098	0.00098	0.0020	0.0016

VI. RESULTS AND GRAPHS

Table 5. RESULTS (SHELL SIDE HOT FLUID) BY KERN METHOD

Sl.no	Shell side	R1	R2	R3	R4	R5
1	Mass flow rate (Kg/sec)	0.0255	0.0314	0.0343	0.041	0.0446
2	Temperature at inlet (oc)	55.5	55.8	56.2	56.3	56.3
3	Temperature at outlet (oc)	44.5	44.7	44.7	45	45.3
4	Reynolds number	65.644	80.832	88.297	105.802	114.812
5	Prandtl number	1.228	1.228	1.228	1.228	1.228
6	Heat transfer coefficient (W/ m2'K).	0.355	0.398	0.418	0.462	0.483
7	Pressure drop (Pa)	0.031	0.045	0.053	0.074	0.085
8	Over all heat transfer coefficient	0.431	0.547	0.66	0.924	1.385

Sl.no	Tube side	R1	R2	R3	R4	R5
1	Mass flow rate (Kg/sec)	0.0199	0.0251	0.0301	0.035	0.0406
2	Temperature at inlet (oc)	35.8	36.1	36.3	36.7	36.8
3	Temperature at outlet (oc)	40.1	40	39.8	40.1	40
4	Reynolds number	205.658	259.432	311.11	361.757	419.638
5	Prandtl number	3.674	3.674	3.674	3.674	3.674
6	Heat transfer coefficient (W/ m2'K).	-1.11	-0.944	-0.82	-0.719	-0.62
7	Pressure drop (Pa)	1.445	2.102	2.839	3.659	4.711

Table 6. RESULTS (TUBE SIDE HOT FLUID) BY KERN METHOD

Sl.no	Shell side	R1	R2	R3	R4	R5
1	Mass flow rate (Kg/sec)	0.0253	0.030	0.035	0.040	0.044
2	Temperature at inlet (°c)	32.4	34.7	34.7	34.7	34.7
3	Temperature at outlet (°c)	32.4	32.8	32.9	33.1	33.2
4	Reynolds number	65.129	77.228	90.099	102.97	113.267
5	Prandtl number	3.67	3.67	3.67	3.67	3.67
6	Heat transfer coefficient (W/m^2K)	0.167	0.184	0.2	0.215	0.227
7	Pressure drop (Pa)	1.503	2.13	2.983	3.748	4.731
8	Over all heat transfer coefficient	0.146	0.162	0.18	0.199	0.219

Sl.no	Tube side	R1	R2	R3	R4	R5
1	Mass flow rate (Kg/sec)	0.0204	0.0253	0.031	0.0355	0.0407
2	Temperature at inlet (°c)	49	50.3	50.8	51.1	51.5
3	Temperature at outlet (°c)	42.4	42.9	43.4	44.3	44.7
4	Reynolds number	210.853	261.499	320.413	366.925	420.672
5	Prandtl number	2.401	2.401	2.401	2.401	2.401
6	Heat transfer coefficient (W/m^2K)	-1.303	-1.116	-0.948	-0.839	-0.73
7	Pressure drop (Pa)	1.503	2.13	2.98	3.748	4.731

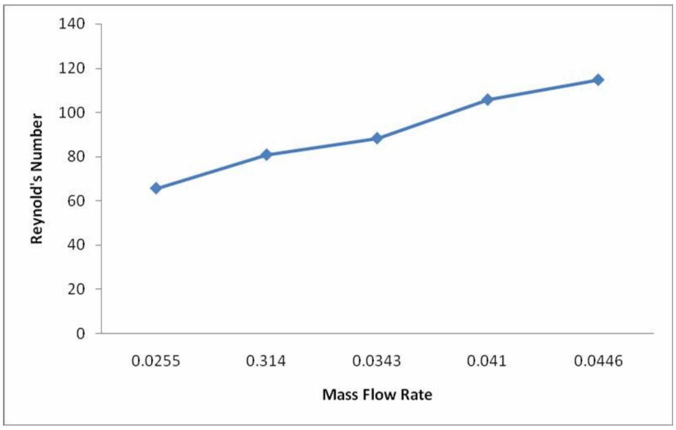

Fig 2. Reynolds Number V/S Mass Flow rate

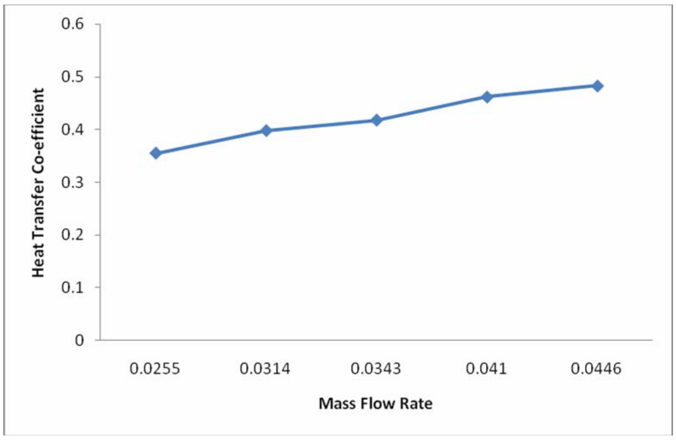

Fig 3. Mass Flow Rate V/S Heat Transfer Coefficient

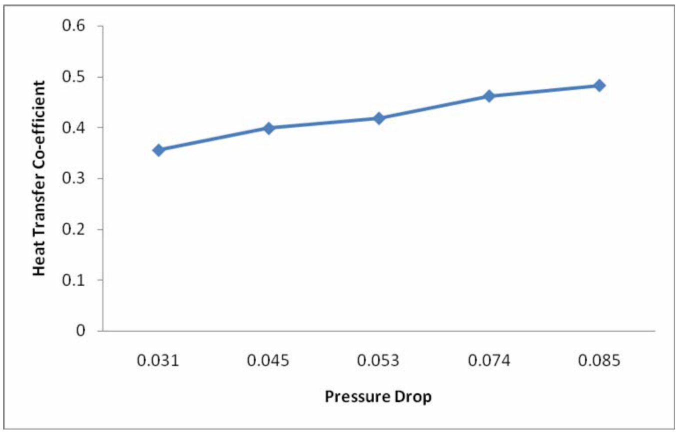

Fig 4. Pressure Drop V/S Heat transfer Coefficient

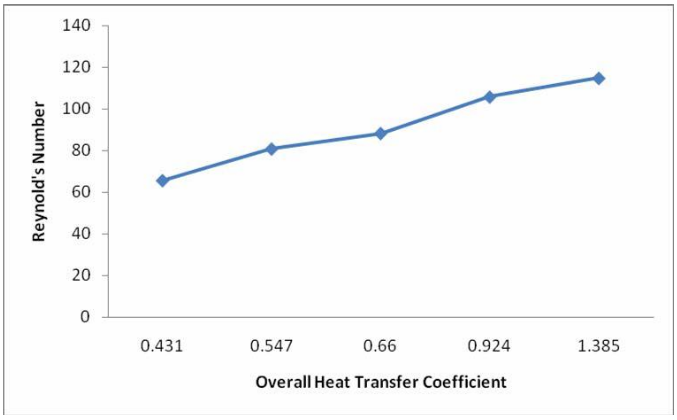

Fig 5. Over all Heat Transfer coefficient V/S Reynolds Number

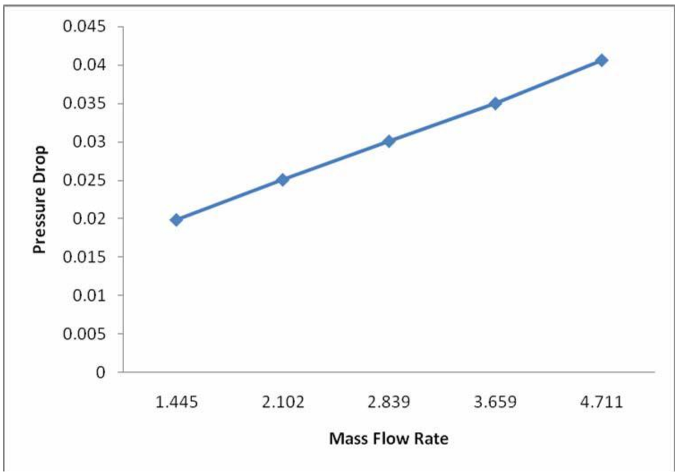

Fig 6. Pressure Drop V/S Mass flow rate on tube side

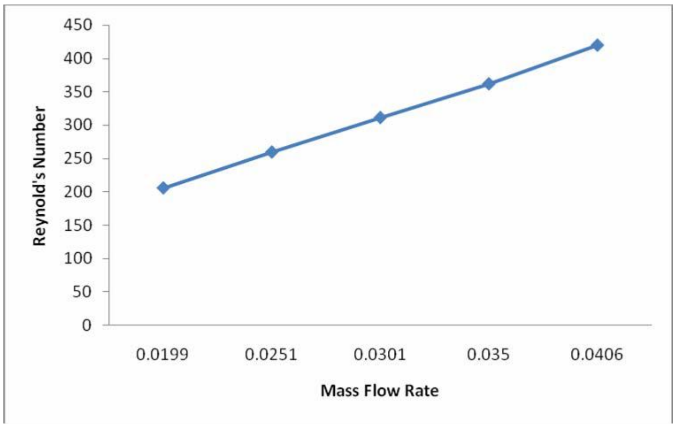

Fig 7. Reynolds number V/S Mass Flow rate on Tube side

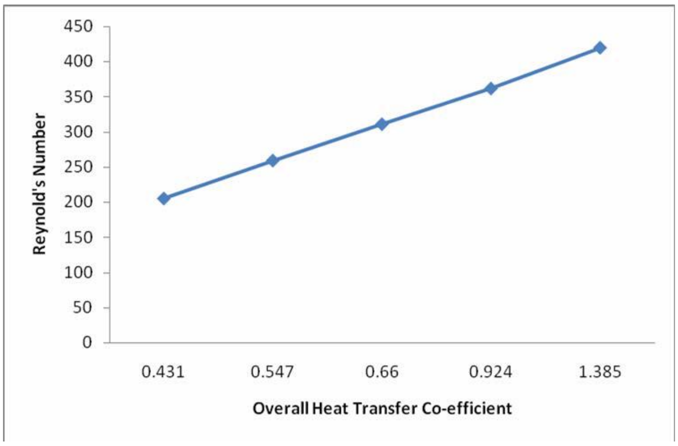

Fig 8. Reynolds number V/S Over all Heat transfer coefficient on shell and tube side

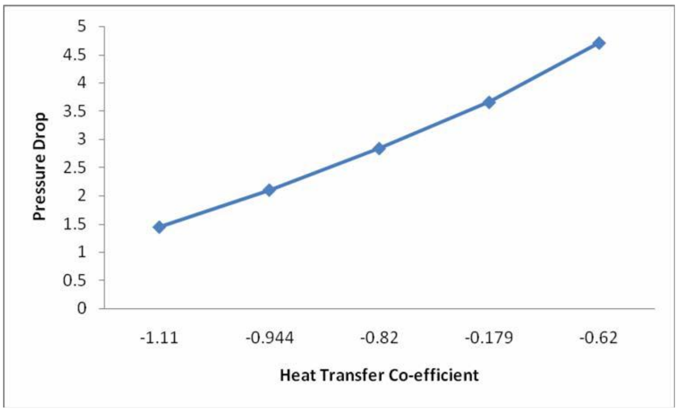

Fig 9. Heat transfer coefficient V/S Pressure Drop

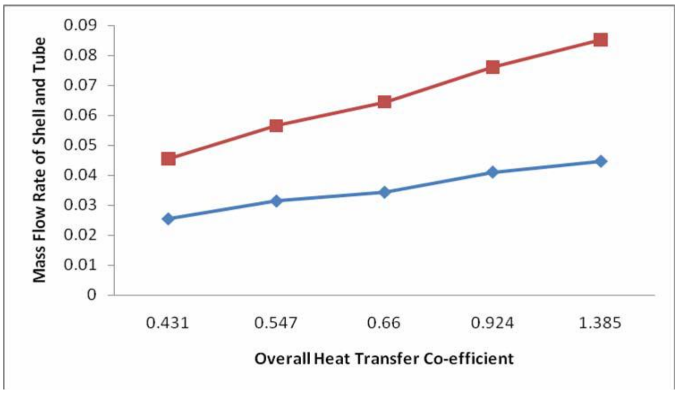

Fig 10. Mass Flow rate V/S Over all Heat transfer coefficient on shell and tube side

VII. CONCLUSION

This method of analyzing the heat exchanger using the Nano fluid gives the satisfactory result even though the analysis is not conducted in full labrotical conditions.

The results obtained shows the better thermal conductivity than the conventional fluids when used the nano fluids and simpler.

The nano fluids produced by using the neem leaf and guava leaf shows a stable nano fluids And they are stable for about 6 months and the process is simpler.

In future it is desired to experiment with the compact smaller heat exchangers as the results might be better than the proposed one. And the experiment needs to be conducted with the other nano fluids to know how they will effect in improving the thermal efficiency .

VIII. REFERENCES

[1] Deshpande raghunandan.bedre d Mahesh. S baswaraja. S d balaji. S y manjunath. A venkatraman; "microwave –assisted rapid extracellular synthesis of bio-functionalized silver nanoparticles from guava leaf extract" ; hke's college of pharmacy sedum road, Gulbarga, Karnataka, india .

[2] Sandeep K. Patel, Professor Alkesh M. Mavani "shell & tube heat exchanger thermal design with optimization of mass flow rate and baffle Spacing" .d.r.p – i.t.r, gandhinagar, Gujarat., india

[3] B.V. Babu, Professor S.A. Munawar: Differential evolution strategies for optimal design of shell-and-tube heat exchangers. Department of Chemical Engineering Birla Institute of Technology and Science PILANI-333 031 . Rajasthan, India.

[4] Rajiv Mukherjee: Effectively Design Shell-and-Tube Heat Exchangers February 1998 • Chemical Engineering Progress Copyright 1997 American Institute of Chemical Engineers.

[5] L.B. Mapa, Sana Mazhar “Heat transfer in mini heat exchanger using nanofluids “American Society for Engineering Education April 1-2, 2005 –Northern Illinois University, DeKalb, Illinois. 2005 IL/IN Sectional Conference.

[6] Mohammad Hadi Pirahmadian, Azadeh Ebrahimi; Theoretical Investigation Heat Transfer Mechanisms in Nanofluids and the Effects of Clustering on Thermal Conductivity International Journal of Bioscience, Biochemistry and Bioinformatics, Vol. 2, No. 2, March 2012