ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN OF HELICAL BAFFLE IN SHELL AND TUBE HEAT EXCHANGER WITH USING COPPER OXIDE(II) NANO PARTICLE

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ABSTRACT

Heat exchangers being one of the most important heat & mass transfer apparatus in industries like oil refining, chemical engineering, electric power generation etc. are designed with preciseness for optimum performance and long service life. This paper experimental investgation of helical baffle heat exchanger using the Kern method with varied shell side flow rates. This is a proven method used in counter flow design of Heat Exchangers with a baffle cut of 25%. The paper also consists of the thermal analysis of a helixchanger (Continuous Helical baffled Heat Exchanger) using the Kern method, modified to estimate the results for different flow rates at a fixed helical angle of 5,10,15,20˚. The results obtained in this paper show us that the desired properties from a Heat exchanger i.e High Heat Transfer Co-efficient and lower pressure drop are more effectively obtained in a Helixchanger. The shell side zigzag flow induced by the Segmental baffle arrangement is completely eliminated in a Helixchanger. The flow pattern in the shell side of the continuous helical baffle heat exchanger is rotational & helical due to the geometry of continuous helical baffles. This flow pattern, at a certain different helical angles, results in significant increase in the heat transfer coefficient, however at the cost of lower pressure drop.And also using copper oxide(ii) nanao particle wth two different volume concentrations 0.05% and 0.1% .The results are evaluated in terms of heat transfer rate,shell side and tube side heat transfer coefficient and over all heat transfer coffecientand heat transfer area.

KEYWORDS: Kernmethod ,helixchanger, helicalangle, increased heattransfer coefficient, reduced pressure -drop,nanofluid,shell and tube heat exchanger.

INTRODUCTION

Shell and tube heat exchangers (STHXs) are the most common ofthe various types of unfired heat transfer equipment which areused in the industrial fields such as: process industries, conventionaland nuclear power stations, petroleum refining and steamgeneration. Although they are not especially compact, they arerobust and their rugged shapes make them well suited for highpressure operations. Moreover, they are versatile and can bedesigned to suit for almost any application. A variety of different internal constructions are used both in theshell and tube sides of STHXs to achieve the most desirableperformance for vast ranges of operation conditions. Baffles, asimportant components, provide support for tubes, enable a desirablevelocity to be maintained for the shell-side fluid flow, andprevent the tubes from vibrating. Baffles also guide the shell-sideflow to move forward across the tube bundle, increasing fluidvelocity and heat transfer coefficient. . M. Thirumarimurugan, T.Kannadasan and E.Ramasamy [1] have investigated heat transfer study on a solvent and solution by using Shell and Tube Heat Exchanger. In which Steam is taken as the hot fluid and Water and acetic acid-Water miscible solution taken as cold fluid. A series of runs were made between steam and water, steam and Acetic acid solution .The flow rate of the cold fluid is maintained from 120 to 720 lph and the volume fraction of Acetic acid is varied from 10-50%. Experimental results such as exchanger effectiveness, overall heat transfer coefficients were calculated. . MATLAB program was used to simulate a mathematical model for the outlet temperatures of both the Shell and Tube side fluids. The effect of different cold side flow rates and different compositions of cold fluid on the shell outlet temperature, tube outlet temperature and overall heat transfer coefficients were studied..Gang yong Lei et al [2] have showed the effects of baffle inclination angle on flow and heat transfer of a heat exchanger with helical baffles, where the helical baffles are separated into inner and outer parts along the radial direction of the shell. While both the inner and outer helical baffles baffle the flow consistently, smoothly and gently, and direct flow in a helical fashion so as to increase heat transfer rate and decrease pressure drop and impact vibrations, the outer helical baffle becomes easier to manufacture due to its relatively large diameter of inner edge. Lutcha J et al [3] have done experiments to the improvement of tubular heat exchangers with helical baffles for investigation of the flow field patterns generated by various helix angles which is expected to decline pressure at shell side and increase heat transfer process significantly. Pardeep Kumar et al [4], experimental Investigation has been carried-out to know the thermal performance of Helix exchanger with plain copper tubes or with grooved copper tubes of same size and Specification by using co-current flow. During this experimental investigation Attempts were made for both exchangers at same operating conditions and it was found that grooved copper tubes helix changer have a better thermal performance as compared to plain copper tubes helix changer at a particular angle, 25̊. Farajollahi et al. [5] performed an experimental analysis to study heat transfer of nanofluids in a shell and tube heat exchanger. The nanofluids used were Al2O3/water andTiO2/water under turbulent flow conditions to investigate the effects of Peclet number, volume concentration of suspended particles, and particle type on the heat transfer characteristics. The results indicate that addition of nanoparticles to the base fluid enhances the heat transfer performance and results in larger heat transfer coefficient than that of the base fluid at the same Peclet number. Mapaand Mazhar [6]. Tested the effect of nanofluids in mini heat exchanger. Their experiments tested the heat transfer performance in the heat exchanger using water/water as working fluids, and using water and nanofluid with concentration of 0.01% and 0.02% volume. They concluded that nanofluidsenhance the heat transfer rate, and stated that the presence of nanoparticles reduced the thermal boundary layer thickness. Several other researchers have reported similar trend in the increase of heat transfer in conventional fluids by the addition of nanoparticles.

DEVELOPMENT OF SHELL AND TUBE HEAT EXCHANGER

The developments for shell and tube exchangers focus on better conversion of pressure drop into heat transfer i.e. higher Heat transfer co-efficient to Pressure drop ratio, by improving the conventional baffle design. With single segmental baffles, most of the overall pressure drop is wasted in changing the direction of flow. This kind of baffle arrangement also leads to more grievous undesirable effects such as dead spots or zones of recirculation which can cause increased fouling, high leakage flow that bypasses the heat transfer surface giving rise to lesser heat transfer co-efficient, and large cross flow. The cross flow not only reduces the mean temperature difference but can also cause potentially damaging tube vibration.

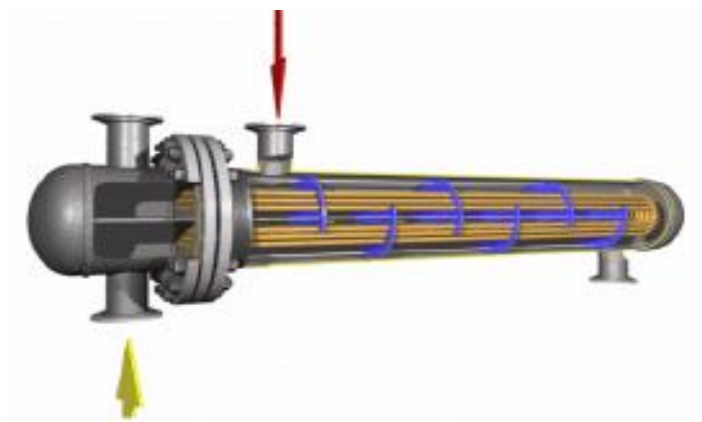

Fig 1 . Helical baffle shell and tube heat exchanger

Helical baffle Heat Exchanger:

The baffles are of primary importance in improving mixing levels and consequently enhancing heat transfer of shell-and-tube heat exchangers. However, the segmental baffles have some adverse effects such as large back mixing, fouling, high leakage flow, and large cross flow, but the main shortcomings of segmental baffle design remain.Compared to the conventional segmental baffled shell and tube exchanger Helix changer offers the following general advantages.

- Increased heat transfer rate/ pressure drop ratio.
- Reduced bypass effects.
- Reduced shell side fouling.
- Prevention of flow induced vibration.
- Reduced maintenance

CuO Nano Particles

The CuO nano particles having an average size of 50 nm and density of 6.3 gm/cm3 is procured from a USA based company (Sigma-Aldrich Chemicals Private Ltd) and is used for investigation in the present experimental work. The distribution of CuO nanoparticles at nano scale can be observed under a Scanning electron microscope (SEM). The SEM images of CuO nanoparticles at 1 µm magnifications .

Fig 2. Copper oxide nano particle

By mixing of nano powder in the base liquid the nanoparticles are directly mixed in the base liquid and thoroughly stirred. Nanofluids prepared in this method give poor suspension stability, because the nanoparticles settle down due to gravity, after a few minutes of nanofluid preparation. The time of particle settlement depends on the type of nanoparticles used, density and viscosity properties of the host fluids. Copper oxide nanofluids of different volume concentrations in take are 0.05, 0.1% are prepared for measuring the temperature dependent thermal conductivity and viscosity of all the nanofluids concentration considered in the present work. Normally agglomeration of nanoparticles takes place when nanoparticles are suspended in the base fluid. All the test samples of CuO nanofluids used subsequently for estimation of their properties were subjected to magnetic stirring process followed by ultrasonic vibration for about 5 hours.

METRIALS AND METHOD

The shell and tube heat exchanger is single pass heat exchanger. The hot fluid is hot water obtained from the electric geyser and cold fluid is tap water. Cold water or nano fluid enters in the lower side of the end box, flows through the tubes in lower half of the shell where it reverse its direction, flows through tubes in upper half of the shell and leaves out. The hot water enters lower part of the shell passes over the tubes between the baffles and leaves out the shell through outlet at upper surface of shell. The flow rates are measured with the help of rota meters. The temperatures at various points in heat exchanger are measured by using Resistance Thermometers. Thus the heat transfer rate, heat transfer coefficient, L.M.T.D and effectiveness of heat exchanger can be calculated.

Important Parameters

- Pressure Drop (ΔPS)
- Helical Baffle pitch angle (ϕ)
- Baffle spacing (LB)
- Equivalent Diameter (DE)
- Heat transfer coefficient (αo)

In designing a helical Baffle Heat Exchanger, the pitch angle, baffle's arrangement, and space between the two baffles with the same position are some of the important parameters. Baffle pitch angle (ϕ) is the angle between the flow and perpendicular surface on exchanger axis and LB is the space between two corresponding baffles with the same position. Optimum design of helical baffle heat exchangers is dependent on the operating conditions of the heat exchanger. Consideration of proper design of Baffle pitch angle, overlapping of baffles and tube's layout results in the optimization of the Heat Exchanger Design. In segmental heat exchangers, changing the baffle space and baffle cut can create wide range of flow velocities while changing the helix pitch angle in helical baffle system does the same. Also, the overlapping of helical baffles significantly affects the shell side flow pattern.

Heat Exchanger data at the shell side:

Table 1.Input data shell side

S.NO	Quantity	Symbol	Value
1	Shell side fluid flow		water
2	Volume flow rate	Q_S	30lpm
3	Shell side mass flow rate	m_s	0.025kg/sec
4	Shell inner diameter	D_{is}	0.1m
5	Shell length	L_S	0.60m
6	Tube pitch	p_t	0.0156
7	No.of passes		1
8	Baffle cut		25%
9	Baffle spacing	L_B	0.055m

Heat Exchanger data at the tube side:

Table 2.Input data tube side

S.NO	Quantity	Symbol	Value
1	Tube side fluid flow		water
2	Volume flow rate	Q_t	30lpm
3	Tube side mass flow rate	M_t	0.05kg/sec
4	Tube OD	D_{ot}	0.0125m
5	Tube ID	D_{it}	0.010m
6	Tube thickness		1mm

Fluid Properties:

Table 3.Fluid properties

property	**Symbol**	**Unit**	**Cold water(Shell)**	**Hot water(Tube)**
Density	$\dot{\rho}$	Kg/m^3	996	996
Specfic heat	C_P	KJ/Kg-k	4.178	4.178
Thermal condutivity	K	W/m-K	0.615	0.615
Viscosity	μ	Kg/ms	0.001	0.001
Prandtl Number	Pr		5.42	5.42

Characteristics of Nanofluids:

Intended for heat exchanger CuO nanofluids with different volume percentages. Using the features provided in the third quarter of nanofluids is calculated. Relations are considered to compute the density, specific heat, thermal conductivity and viscosity are as follows

Density: $\rho_{nf} = (1-\phi)\ \rho_{bf} + \phi\rho_p$

Heat capacity: $(\rho c_{p)nf} = (1-\phi)(\rho c_p)_{bf} + \phi(\rho c_p)_p$

Thermal conductivity: $$K_{nf} = \frac{k_p+2k_{bf}+2(k_p-k_{bf})\phi}{k_p+2k_{bf}-(k_p-k_{bf})\ \phi}$$

Viscocity: $\mu_{nf}=\mu_{bf}(1+2$

*Table 4.*Cuo fluid properties

property	Symbol	Unit	Cuo particle(value)
density	ρ	Kg/m^3	6302
specificheat	c_p	Kt/kg-k	959.1
Themal conductivity	k	W/mk	76.5
viscosity	µ	Kg/ms	-
Prandtl Number	P_r		

RESULTS AND DISCUSSION

Shell Side: Shell is the container for the shell fluid and the tube bundle is placed inside the shell. Shell diameter should be selected in such a way to give a close fit of the tube bundle. shows the results of shell side heat transfer coefficient,and various temperatures increasing the heat transfer coefficient with helical baffles.and also shows the different volume concentrations increasing the heat transfer coefficients.

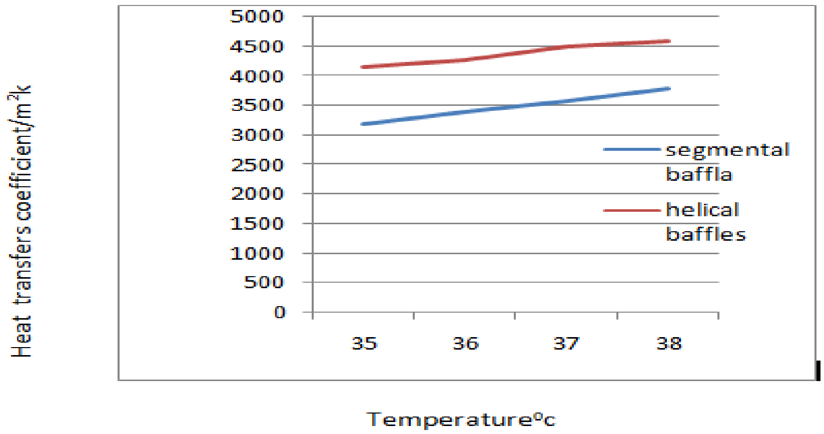

Fig 3.Temprature V$_S$Heat tranfer coefficient(shell side)

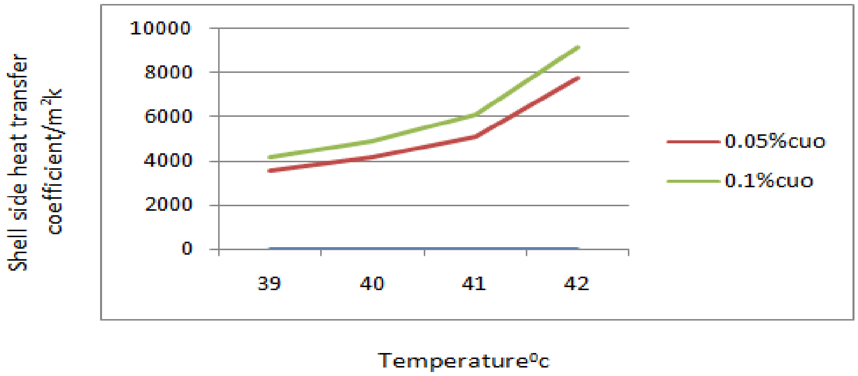

Fig 4.Variation of cocentrations cuo Temperature V$_S$ Heat transfer coefficient

Tube Side: The graphs shows tube side heat transfer coefficient and temperatures .The heat transfer coefficient increases the tube sidewith helical baffles and also plotted the cuo volume concentrations.

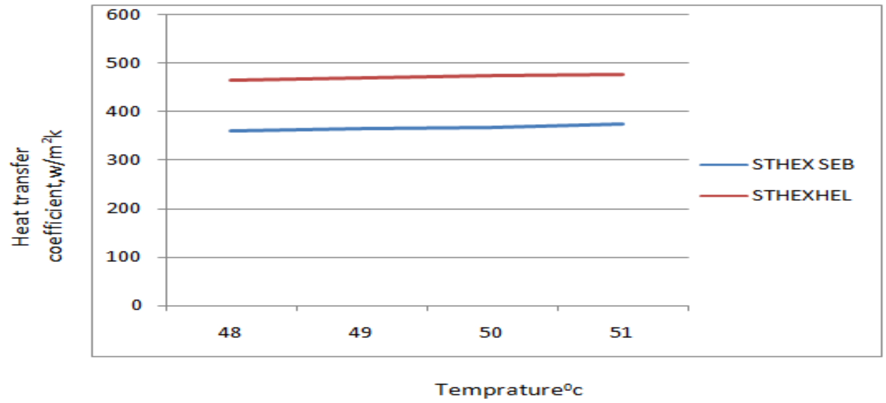

Fig 5.Temperature V_S Heat transfer coefficient(tube side)

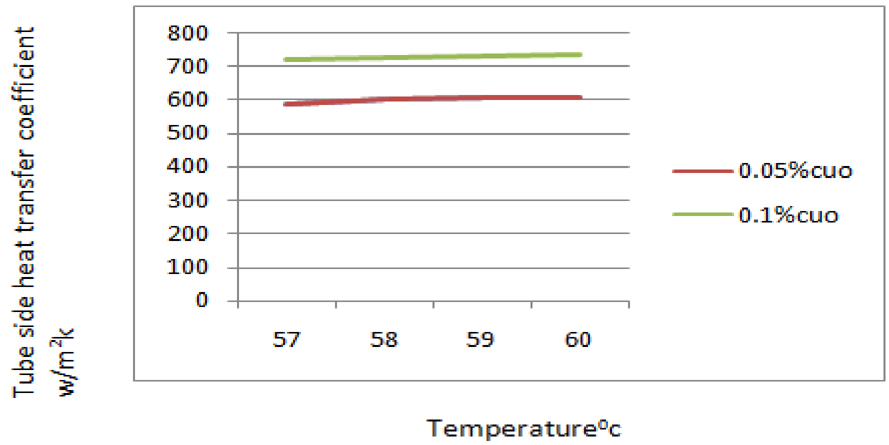

Fig 6. Variation of cocnetration cuo Temperature V_S Heat transfer coefficient

Overall heat transfer coefficient: Overall heat transfer coefficient increased with increase in thetemperature, but Nano fluid having high overall heat transfer coefficientcompared with water. Because of Heat transfer rate of Nanofluid is high, metal particle added into base fluid, so increasing theheat absorbing rate of Nano fluid and increasing the overall heattransfer coefficient comparing with water.

The graphs plotted between helix angle and over all Heat transfercoefficient is shown in the below

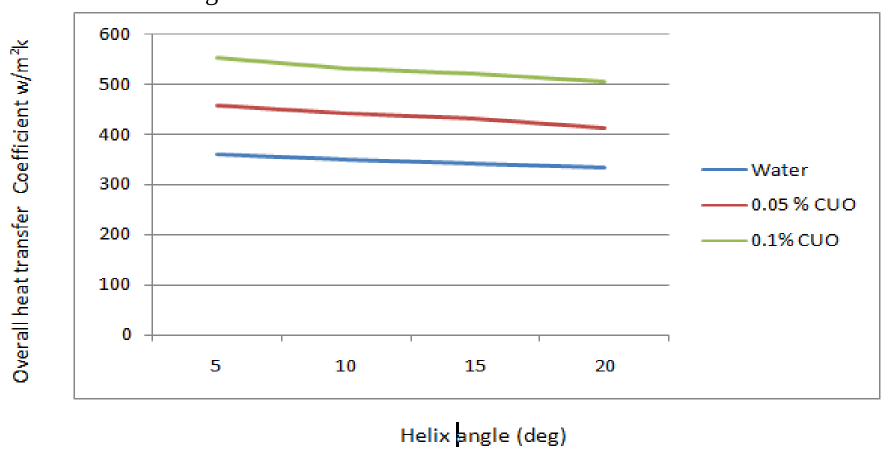

Fig 7. Helix angle V_S Overall heat transfer coefficient

Pressure Drop:Heat transfer requirements an important consideration in heat exchanger design,is the pressure drop.The size of a heat exchanger can be reduced by forcing the fluids through it higher velocities there by increasing the overall heat transfer coefficicent.

The graph plotted between helix angleand Pressure Drop is shown in the below .Thisshows a clear idea that the pressure require to pump in segmental baffle is high when compared with Helicalbaffle. The pressure gradually decreases with the increase in helix angle.

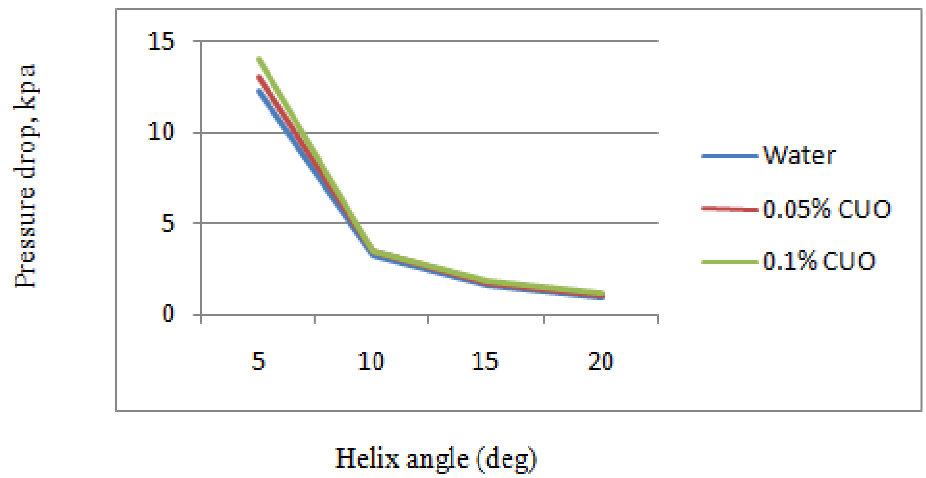

Fig 8. Helix angleV$_S$ Pressure drop

Reynolds number is decreased with decreasing in the temperature,because viscosity of Nano fluid is high, and so decreasingthe friction factor at high temperature and increasing the Reynoldsnumber of Nano fluid, thus decreasing the pressure drop offluid but Nano fluid contain the metal particle, hence the pressuredrop of Nano fluid is high comparing with water.

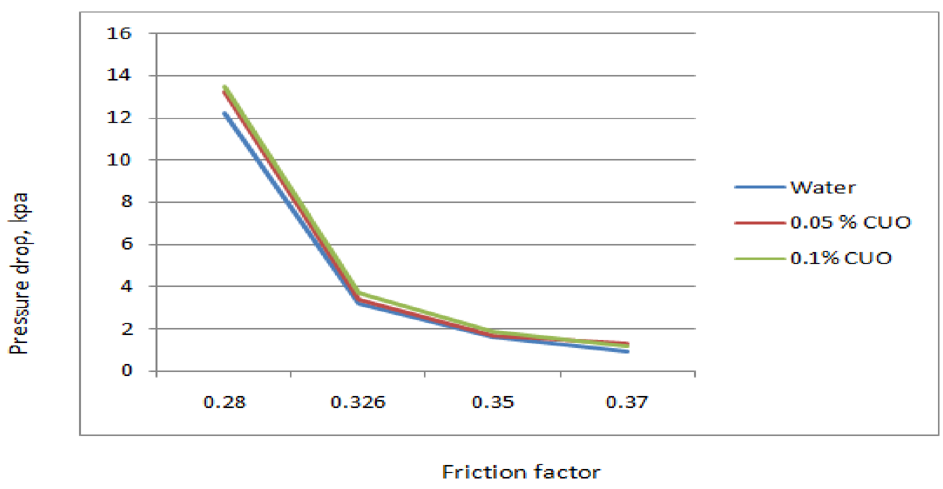

Fig 9 . Friction factor V$_S$ Pessure drop

CONCLUSION

1.The above results give us a clear idea that the helicalbaffle heat exchanger has far more better Overtransfer coefficient than the segmental baffles Heat Exchanger.And also running time will be morethan segmental baffles.
2. In shell side the pressure drops are lowerconventional no baffles heat exchanger. The pressuredrop is decreases with the increases of helix angle in allthe cases considered. However, the effects of helixangles on pressure drop are small when helix anglegreater than 20 degree.
4. The kern method available in the Introduction is onlyfor the segmental baffle Heat exchanger, but themodified formula is used to approximate thermal performance of helical baffle heat exchanger.
5. Suitable helix angle may be selected based upon thedesired output and industriaof 5^0 may provide better heat transfer than the one withan angle of 20^0, however at the expressure drop.
6. The copper oxide(ii) nano fluid is using two different volume concentration 0.05%,0.1% its provide better heat transfer coefficeient ,overall heat transfer coefficientand reduced the pressuer drop.

NOMENCLATURE

Q	Heat transfer rate, W
M	Mass flow ratr, kg/sec
D	Diameter(shell and tube), m
L_B	Baffle Spacing, m
p_t	Tube pitch, m
C_P	Specific heat, KJ/Kg-K
K	Thermal conductivity, W/mK
P_r	Prandtl Number

Greec letters

ρ	Density, Kg/ms
μ	Dynamic visocasity, Kg/m^2s
ϕ	Particle volume concentration

Subscripts

i	Inside condition
o	Out side condition
f	Base fluid
nf	Nano fluid
p	particle

ACKNOWLEDGEMENTS
The authors would like to express their heartfelt gratitude toMr.P.Lakshmi Reddyand Sesha giri rao for their cooperation in theresearch, and to thank full to G.Pulla Reddy Engineering Colleg.kurnool.

REFERENCES

[1] M. Thirumarimurugan, T.Kannadasan and E.Ramasamy, Performance Analysis Of Shell And Tube Heat Exchanger Using Miscible System, American Journal Of Applied Sciences 5 (5): 548-552, 2008J. D. Poston and W. D. Horne, “Discontiguous OFDM considerations for dynamic spectrum access in idel TV channels,” in Proc. IEEE DySPAN, 2005.
[2] Jian-Fei Zhang, Ya-Ling He, Wen-Quan Tao,” A Design And Rating Method For Shell-And-Tube Heat Exchangers With Helical Baffles, Journal Of Heat Transfer, May 2010.
[3] Lutcha J, et al, “Performance improvement of tubular heat exchangers by helical baffles,” Chemical Engineering Research and Design, **68**, 263-270 **(1990).**
[4] Pardeep Kumar et al**,** “Experimental Study on Heat Enhancement of Helix changer with Grooved Tubes,”, University institute of Engineering &Technology, KUK, Haryana, India, IJLTET Vol. 3 Issue 4 March 2014ISSN: 2278-621X (2014).
[5] B. Farajollahi, S.Gh. Etemad, M. Hojjat, Heat transfer of nanofluids in a shell and tube heat exchanger, Int. J. Heat Mass Transfer 53 (2010) 12–17.

[6] L.B. Mapa, S. Mazhar, Heat transfer in mini heat exchanger using nanofluids, Sectional Conference, American Society for Engineering Education, Illinois, 2005.
[7] Peng B, Wang Q.W, Zhang C**, "**An experimental study of shell and tube heat exchangers with continuous helical baffles", ASME Journal of Heat transfer, 129:1425-1431 (2007)
[8] V K PRAVIN et al, "Experiential investigation of shell and tube heat exchanger using kern method," IJPRET, 2014; Volume 2 (6): 64-82
[9] H.A. Mohammeda,, G. Bhaskaran a, N.H. Shuaib a, R. Saidur Numerical study of heat transfer enhancement of counter nanofluids flow in rectangular micro channel heat exchanger 28 June 2011.
[10] W. Roetzel, D. Lee, Experimental investigation of leakage in shell-and-tube heat exchangers with segmental baffles, International Journal of Heat and Mass Transfer 36 (15) (1993) 3765–3771.
[11] R. Hosseini, A. Hosseini-Ghaffar, M. Soltani, Experimental determination of Shell side heat transfer coefficient and pressure drop for an oil cooler shell and tube heat exchanger with three different tube bundles, Applied Thermal Engineering . 27 (2007) 1001–1008.
[12] H.D. Li, V. Kottke, Effect of the leakage on pressure drop and local heat transfer in shell-and-tube heat exchangers for staggered tube arrangement, International Journal of Heat and Mass Transfer 41 (2) (1998) 425–433.
[13] M. Reppich, S. Zagermann, New design method for segmentally baffled heat exchangers, Comput. Chem. Eng. 19(Suppl.) (1995) S137–S142.
[14] S.U.S. Choi, Z.G. Zhang, W. Yu, F.E. Lockwood, E.A. Grulke, Anomalously thermal conductivity enhancement in nanotube suspensions, Appl. Phys. Lett. 79 (2001) 2252–2254.
[15] H. Masuda, A. Ebata, K. Teramae, N. Hishinuma, Alteration of thermal conductivity and viscosity of liquid by dispersing ultra-fine particles (Dispersion of g-Al2O3, SiO2, and TiO2ultra-fine particles), Netsu Bussei. 7 (1993) 227–233.