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DESIGN , FABRICATION AND EXPERIMENTAL ANALYSIS OF SHELL AND HELICAL COILED HEAT EXCHANGER USING NANOFLUIDS

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ABSTRACT - Heat exchangers are the important engineering equipments used for transferring heat from one fluid to another. Heat exchangers are widely used in various kinds of application such as power plants, nuclear reactors, refrigeration and air-conditioning systems, heat recovery systems, petrochemical, mechanical and biomedical industries. Now days helical coiled heat exchangers are used in many large thermal industries because it can give high heat transfer coefficient in small footprint of surface area.This project focuses on the designing of shell and helical coiled heat exchanger and its thermal evaluation with cross flow configuration. In this project work, analysis will be carried out by considering the various parameters such as flow rate of cold water, flow rate of hot water, temperature, effectiveness and overall heat transfer coefficient etc. In this work, copper material is used for tube pass in helical coiled heat exchanger because of copper has good thermal conductivity(K) is 385w/m.k. So that it can give better results for improving overall performance of helical coiled heat exchanger. Finally result will be evaluated by varying mass flow rate of cold medium with different concentration of nanofluids.

KEYWORDS: Shell and helical coiled heat exchanger, Copper, Thermal conductivity ,nanofluids.

INTRODUCTION

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In most Industries, the designing and thermal evaluation of heat exchangers is generally carried out in order to reduce cost, material and energy and to obtain maximum heat transfer. The main challenge in heat exchanger design is to make it compact and to get maximum heat transfer in minimum space. The passive enhancement technique using coiled tube has significant ability in enhancing heat transfer by developing secondary flow in the coil. Due to enhanced heat transfer the study of flow and heat transfer in helical coil tube is of vital importance. The first attempt has been made by Amol Andhare et al . [1] heat exchangers have significant applications in refrigeration & air-conditioning systems, heat recovery processes, chemical reactors, food processing, power engineering and other energy intensive industries. The design of an efficient heat exchanger had always been significant to equipment designers. Due to their compact structure and high heat transfer coefficient, helical coils as one of the passive heat transfer enhancement technique is widely used in various industrial applications. The centrifugal force induced due to the curvature of the tube results in the secondary flow development which enhances the heat transfer. Numerous studies have been carried out by researchers to investigate the fluid flow and heat transfer characteristics in the coiled tubes. Dravid et al. [2] in the fully developed region and the thermal entrance region studied the effect of secondary flow on laminar flow heat transfer in helically coiled tubes. The results obtained from predictions were validated with those obtained from experiments in the range in which they overlapped. Patankar et al [3] has studied the effect of the Dean number on friction factor and heat transfer in the developing and fully developed regions of helically coiled pipes. Good agreements were obtained from comparisons between the developing and fully developed velocity profiles, the wall temperature for the case of axially uniform heat flux with an isothermal periphery obtained from calculation and those obtained from experiments. In the model mentioned above, the effects of the torsion and the Prandtl number were not taken into account. Rennie et al [4] investigated performance of a double pipe helical heat exchanger. The overall heat transfer

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coefficients were calculated and heat transfer coefficients in the inner tube and annulus were determined using Wilson plots. Results revealed that there was significant increase in Nusselt number in the entrance region and also heat transfer rates in counter flow configuration. Ghorbani et al [5] has studied the experimentally investigated the mixed convection in helically coiled heat exchanger for various Reynolds numbers, Rayleigh's number, various tube-to-coil diameter ratios and different dimensionless coil pitch for both laminar and turbulent flow inside coil. The mass flow rate of tube side to shell side ratio (Rm) was found to be effective on the axial temperature profile of heat exchanger. Srbislav B.et al [5] ,have studied to establish a reliable procedure for estimation of air pressure drop, extensive investigation of the open literature has been conducted. The equations from mostly cited literature sources were tested against the experimental data given in the open literature and certain level of uncertainty was found. Using published experimental data, new correlations for estimation of air pressure drop in helically-finned tube bundles with in-line and staggered tube arrangement have been established. Chosen form of correlations successfully describes operating regimes for wide range of Reynolds number and geometrical parameters.E. Martinez et al [6] , have concluded this methodology for designing helically serrated finned tube heat exchanger based on the logarithmic Mean Temperature Difference (LMTD) method is validated with experimental tests. The method uses semi-empirical correlations for calculating convective coefficients both inside and outside staggered tube bundles. Equipment was designed, built, and installed in a paper factory in order to validate the methodology. Comparisons between predictions and experimental data show a precision of approximately 96% in heat transfer and approximately 90% in pressure drop for Reynolds numbers upper to 10,000. W.Vicente et al [7] have studied the helical segmented fins of uniform profile are analyzed by means of the quasi one- dimensional fin theory coupled with the Logarithmic Mean Temperature Difference (LMTD) method from heat exchanger theory to determine the optimum fin dimensions. On

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one hand, the quasi one-dimensional fin theory is applied to establish the lower fin height limit, which is critical in this type of application. On the other hand, the LMTD method is used to define the optimal equilibrium point by way of the dimensionless overall heat transfer coefficient and the pressure drop. The methodology to be proposed for estimating the optimal dimensions of helical fins was applied to a bare tube with outside diameter of 50.8 mm (2 in) and a maximum transverse pitch based on a bare tube with outside diameter 2.25 larger. The computed results demonstrate that the optimal equilibrium point is affected by the lower fin height limits because it is unstable. Hence, two lower fin height limits are defined in order to determine a maximum deviation of the optimal equilibrium point, while the upper fin height limit is defined by physical-technical limiting factors. Thereby, the optimal equilibrium point predictions show a maximum deviation of 8% and a stable behavior under the influence of different thermal conditions and flow regimes associated with various helically segmented sizes, helical fin heights. J.Y Jang et al [8] , have studied the heat transfer and Fluid Flow over a 4 row circular finned-tube heat exchanger are studied numerically and experimentally. Two types of finned- tube configurations have been investigated under the dry and wet conditions for different values of inlet frontal velocity ranging from 2 to 6 m/s.The experimental results indicated that the sensible colburn factor js for the wet coils is 20% higher than that for the dry coils; the friction factor f for the wet coils is 15% higher than that for the dry coils. The three- dimensional numerical result of laminar model for the pressure drop are in good agreement with the experimental data, while overestimate 200% of the heat transfer coefficient.

NOMENCLATURES

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A	Surface area of coiled tube, m^3
Pr	Prandtl number
D_c	Coil Diameter, m
D	Coiled tube diameter , m
D	Shell diameter, m
H	Averaged Convective heat transfer coefficient, W/m^2k
K	Thermal conductivity, W/m^2k
L	Heat exchanger length , m
M	Mass flow rate, kg/s
N	Number of turns
Q	Heat transfer rate, W
T	Temperature, ^0C
U_0	Overall heat transfer coefficient , W/m^2k
Re	Reynolds number

Greek Letters

M	Viscosity, $N\text{-}s/m^2$
P	Density, kg/m^3
Δ	Delta

Subscripts

I	Inlet condition

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O	Outside condition
H	Hot fluid
C	Cold fluid
Avg	Average
Min	Minimum
Max	Maximum

GEOMETRY OF HELICAL COILS

The schematic diagram shows dimensional and operating parameters of helical coil heat exchanger.

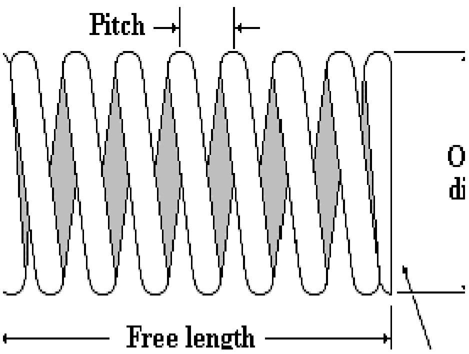

Fig-1 Schematic of shell and helical coil

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EXPERIMENTAL PROCEDURE

The schematic diagram of the experimental set up is as shown in Fig.2. The experimental set up consists of a shell in which the helical coil copper tube is placed through which hot water is made to flow with the help of a centrifugal pump. To ensure maximum heat transfer the copper helical coil is fully immersed in the cold water flowing through the shell, the inlet and outlet are so placed as shown in Fig.2.The shell is well insulated so as to avoid the heat loss to the surrounding. The main components in the set up include centrifugal pump, heating element, cold water storage tank and hot water storage tank. The heat exchanger which includes the helical copper tube and insulated shell is perfectly sealed so as to avoid the leakage of hot water flowing through tube and cold water flowing through shell in a counter flow manner. The water in the storage tank is heated using a heating element, as the water reaches to a prescribed temperature. The centrifugal pump circulates the hot water through the helical coil. The inlet and outlet temperatures of hot and cold water were recorded using thermocouples. The tube and shell side thermo-physical properties of water were assessed at their mean temperatures.

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Fig.2 Experimental Setup

PARAMETRIC ANALYSIS

The readings are taken on horizontally arranged counter flow helical coil heat exchanger and effect of flow rate on effectiveness, overall heat transfer coefficient, heat transfer and outlet hot water temperature is studied.

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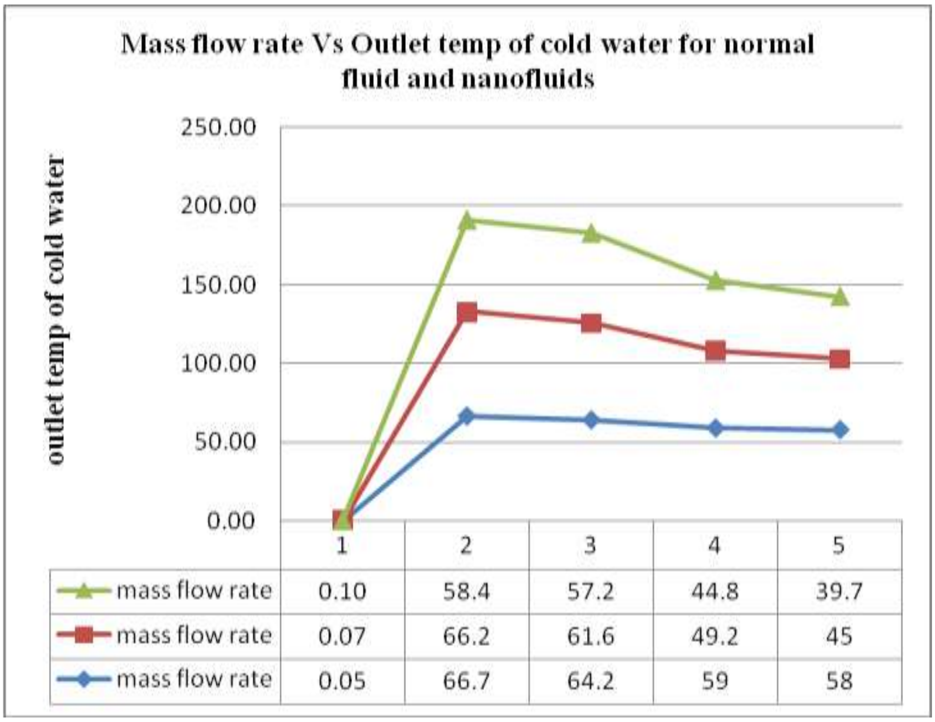

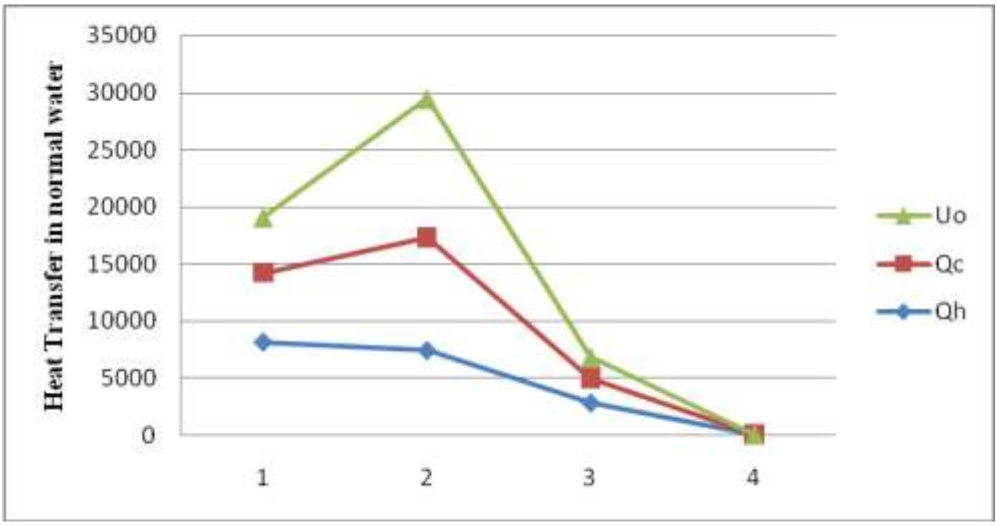

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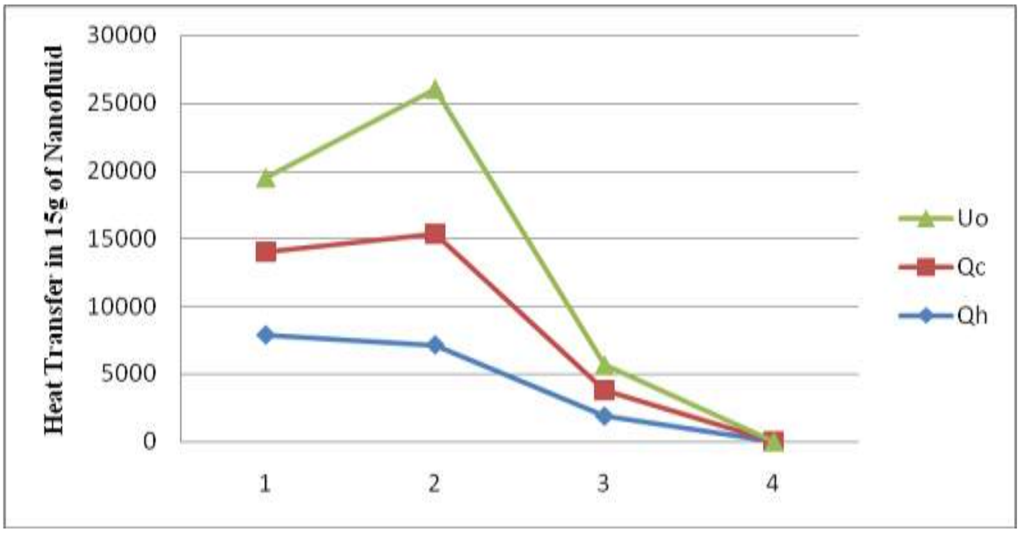

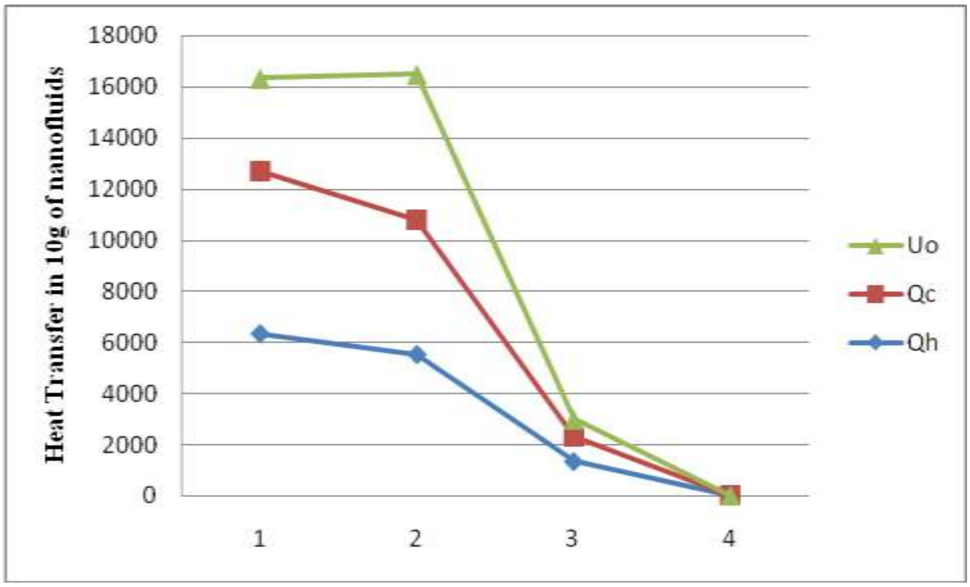

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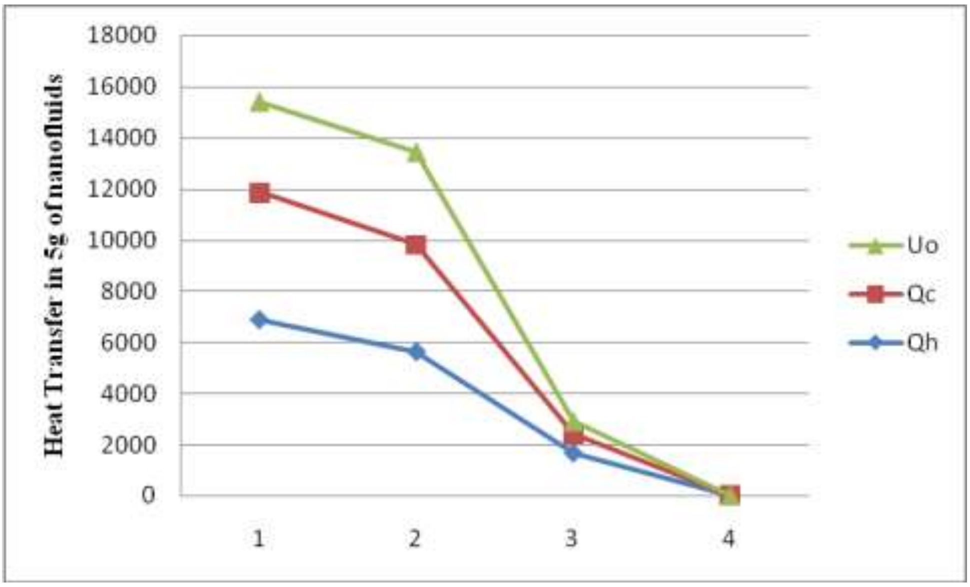

The temperature of hot water at outlet increases with increase in mass flow rate of hot water inside the tube. More amount of heat transfer takes place as mass flow rate of cold water on shell side increases.

CONCLUSION

The present project work entitled "Design, Fabrication and Experimental Analysis of Shell and Helical Coiled Heat Exchanger Using Nanofluids". In this work, the overall heat transfer coefficient and Effectiveness were calculated by using nanoparticle for various mass flow rate and cold water temperature. It has been decided to use nanoparticles Zn of size 30-50 nm each. There are three concentrations of nanoparticles were taken to compare the performance overall heat transfer coefficient and Effectiveness. The system was changed with cold water + nanofluid of Zn with 5g, 15g and 10g of Nanoparticles concentration.Comparing the performance of overall heat transfer coefficient and Effectiveness of normal water and nanofuids of Zn were studied.

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REFERENCES

1. Amol Andhara et al, (2014)Thermal Analysis of a Helical Coil Heat Exchanger,Int.journal,Vol.16(3):363-368.

2. Patankar et al, (2013)-The effect of the Dean number on friction factor and heat transfer in helical coil, Int journal,Vol.17(4):1104-1110.

3. Ghorbani et al ,(2013)-Experimentally investigated the mixed convection in helically coiled heat exchanger, Int.Communication of Heat Mass Tran, Vol.23 (3), pp.321–330.

4. Parinya pongsoi et al, (2012)- Experimentally analysis of helically coiled heat exchanger, Int.Communication of Heat Mass Tran, Vol.22 (3), pp.231–240.

5. Dravid, A.et al, (1971)―Effect of secondary fluid motion on laminar flow heat transfer in helically coiled tubes‖, AIChE Journal, Vol.17(5):1114-1122.

6. Mooyeon Lee, et al ,(2013)- Investigate the air-side heat transfer characteristics of spiral-type circular fin-tube heat exchangers,Int.journal,Vol.15(4),pp.431-440.

W.A. Khan a, et al, (2010)- Analytical study to heat transfer from tube banks in cross flow, Int.Communication of Heat Mass Tran, Vol.19 (3), pp.114–125.

8. Srbislav B. et al ,(2007)- Thermal performance and pressure drop of the helical-coil heat exchangers with and without helically crimped fins, Int.Communication of Heat Mass Tran, Vol.34 (3), pp.321–330.

9. E. Martinez, et al ,(2006) ―A review of flow and heat transfer characteristics in curved tubes‖, Renew. Sust.Energ., Rev. 10, pp. 463–490.

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10. W. Vicente ,et al, -Streamline Flow through Curved Pipes, Proceedings of the Royal Society of London, Series A 123(792)(1929) 645-663.

11. R.A. Seban,et al, Heat transfer in Tube Coils with Laminar and Turbulent Flow, International Journal of Heat and Mass Transfer, 6(1963) 387-395.