International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 01 | Jan -2017 www.irjet.net p-ISSN: 2395-0072

A Review- Comparative Study of Thermal and Hydrostatic Performance Analysis Of Helical Coil Heat Exchanger & Simple Straight Tube Heat Exchanger

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ABSTRACT

Nowadays Heat exchangers are used to transfer heat from fluid at high temperature to fluid at lower temperature. Heat exchangers are used in industrial purposes in chemical industries, nuclear power plants, refineries, food processing, etc. Sizing of heat exchangers plays very significant role for cost optimization. The aim of this study is to determine advantage of using a helically coiled heat exchanger against a straight tube heat exchanger. It is found that the heat transfer in helical circular tubes is higher as compared to Straight tube due to their shape. Helical coils offer advantageous over straight tubes due to their compactness and increased heat transfer coefficient. Also, efficiency of heat exchangers is an important parameter while selection of industrial heat exchangers. Methods for improvement on heat transfer have been worked upon for many years in order to obtain high efficiency with optimum cost .In this current research work various parameters are checked out for investigation for thermal performance and hydrostatic properties for comparing helical coiled heat exchanger and simple tube heat exchanger. Parameters such as heat transfer coeff, mass flow rate, Reynolds no, Nusselt number, friction factor etc. It includes the consideration of the effect of important parameters such as flow rate, coil curvature ratio, pitch of helical coil, length of the tube, correlations developed under various conditions, types of flow, etc. on heat transfer rate.

***Key Words**: (Helical coil heat exchanger, Straight tube heat exchanger, overall heat transfer coefficient)*

1. INTRODUCTION

Heat exchanger is a device that continuously transfers heat from one medium to other medium in order to carry process energy. A heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact.

It is found that the heat transfer in helical circular tubes is higher as compared to Straight tube due to their shape.Helical coils offer advantageous over straight tubes due to their compactness and increased heat transfer coefficient

Energy saving is major matter in our global world, and heat exchanger is very useful for energy saving. Of course heat exchanger is most significant component for chemical reaction, distillation, dissolution, crystallization, fermentation etc. So the correct selection of heat exchanger is important in these process industries

Heat exchangers are used in a wide variety of applications including power plants, nuclear reactors, refrigeration and air-conditioning systems, automotive industries, heat recovery systems, chemical processing, and food industries .Besides the performance of the heat exchanger being improved, the heat transfer enhancement enables the size of the heat exchanger to be considerably decreased. In general, the enhancement techniques can be divided into two groups: active and passive techniques. The active techniques require external forces like fluid vibration, electric field, and surface vibration. The passive techniques require special surface geometries or fluid additives like various tube inserts. Both techniques have been widely used to improve heat transfer performance of heat exchangers. Due to their compact structure and high heat transfer coefficient, helically coiled tubes have been introduced as one of the passive heat transfer enhancement techniques and are widely used in various industrial applications.

The use of helically coiled exchangers continues to increase. Applications include liquid heating/cooling, steam heaters, vapor-izers, cryogenic cooling and vent condensing. Several studies have indicated that helically coiled tubes are superior to straight tubes when employed in heat transfer applications .The centrifugal force due to the curvature of the tube results in the secondary flow development which enhances the heat transfer rate. This phenomenon can be beneficial especially in laminar flow regime.

2.LITERATURE REVIEW

The Primoz Poredos et al. [1] have studied the thermal characteristics of a concentric-tube helical coil heat exchanger which is a key element in local ventilation device. Central element of local ventilation device is concentric tube heat exchanger which is made of a corrugated tube surface. The heat transfer rate can be increased by increasing the convective heat transfer coefficient or by increasing the heat transfer surface area. So they have formed corrugated tube concentric counter flow heat exchanger which have sinusoidal, wavy surface in longitudinal direction of inner tube, which enables heat transfer enhancement. Wilson plot method is used to determine convective heat transfer coefficient on inside and outside of inner tube of concentric tube heat exchanger with different corrugation ratios. It is found that highest heat transfer rate was obtained for maximum stretched tube with corrugation ratio of 1.401, which enables greater effectiveness or a more compact design of concentric tube counter flow heat exchanger. In comparison with smooth tube, the corrugated tube had a 1.104-3.955 times higher value of heat transfer surface area and also pressure drop is 3-3.5 times higher than in smooth tube.

The Hamed Sadighi Dizaji et al. [2] had experimentally investigated heat transfer and pressure drop characteristics for new arrangements of convex and concave corrugated tube in a double pipe heat exchanger. Both of the inner and outer tubes were corrugated by means of a special machine. Convective heat transfer coefficient was determined using Wilson plots. Hot water (inner tube) and cold water (outer tube) inlet temperatures were maintained at around 40 degree and 8 degree respectively. Experiments were performed over the Reynolds number range of 3500-18,000, based on the hydraulic diameter of the annular space between the two tubes. The main purpose of this paper to compare a double pipe heat exchanger made of corrugated inner tube and smooth outer tube with a double pipe heat exchanger made of corrugated inner tube and corrugated outer tube. The results show that use of corrugated tubes is advantageous to enhance the Nusselt number and performance of heat exchanger. It is found that when both of the inner and outer tubes were corrugated, the Nusselt number and friction factor increased about 23-117% and 200-254%, while for only inner tube corrugated of double pipe heat exchanger nusselt number and friction factor were increased up to 10-52% and 150-190% respectively.

The Hamed Sadighi Dizaji et al. [3] had done exergy analysis for shell and tube heat exchanger made of corrugated shell and corrugated tube. The main of this paper is to experimentally clarify the effect of outer tube (shell) corrugations on heat transfer rate, dimensionless exergy loss and number of heat transfer units in a shell and tube heat exchanger. Various arrangements of convex and concave type of corrugated tube were also investigated. The results show that use of corrugated tube as the tube of the shell and tube heat exchanger increases the dimensionless exergy loss about 4% - 31%, while if both tube and shell are corrugated, the dimensionless exergy loss increases about 17% - 81% .In comparison with smooth tube and smooth shell if just the tube is corrugated Number of Transfer Units(NTU) increases about 12% - 19% while if in addition to the
tube, shell is corrugated as well, the NTU increases about 34% - 60% respectively. Thus maximum NTU was obtained for the heat exchanger made of corrugated tube and corrugated shell.

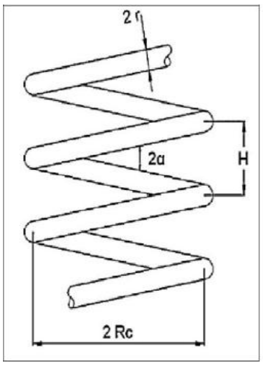
The Shinde Digvijay D. et al. [4] studied the experimental investigation on heat transfer in cone shaped helical coil heat exchanger. They also compared heat transfer in cone shaped helical coil heat exchanger with simple helical coil heat exchanger. For comparative analysis they used both coils with (9.53mm outer dia.),(8.41mm inner dia.) & axial length of 6096mm. for simple helical coil 7 turns & for conical coil 10 turns with cone angle 65. The experiment is conducted for different flow rates and calculations are carried out. It was found that the effectiveness of cone shaped helical coil heat exchanger is more as compared to simple helical coil. In case of cone shaped helical coil heat exchanger Nusselt no. is higher than simple helical coil. They were found that the heat transfer rate for cone shaped helical coil is more as compared to simple helical coil. The heat transfer rate for cone shaped helical coil is 1.18 to 1.38 times more as compared to simple helical coil.

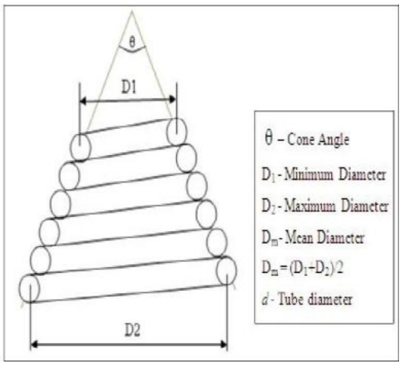
The S. Perumal et al. [5] reviewed on better techniques for enhancing a heat transfer rate. There are mainly two techniques active and passive techniques. They did CFD analysis and experimental studies of different techniques like treated surfaces, rough surfaces, swirling flow devices, coiled tubes. It is found that heat transfer rate of enhanced techniques is greater than that of plane tube. The CFD modelling and experimental results showed that an increase in turbulence intensity could be one of the reasons for higher performance augmentation methods with the plain tubes heat exchanger. The results of corrugated tubes, dimpled tubes and wire coils are compared with plane tube it is found that treated surfaces are having high heat transfer coefficient

The Rennie and Raghavan [6] experimentally investigated that two heat exchanger having same sizes and both parallel flow and counterflow configurations were tested. Copper tube with curvature ratio 233.5mm is used and small holes on the outer tubes to ensure that inner tube is centred, several reading are taken for parallel and counter flow arrangement it is found that heat transfer rate is large for counter flow arrangement because of large log mean temperature difference. They varied inner and outer tubes mass flow rate to modify dean number linearly, as dean number increases heat transfer rate also increases.

H. Shokouhmand, M.R. Salimpour, M.A. Akhavan-Behabadi [7] Have done an experimental investigation of the shell and helically coiled tube heat exchangers. Three heat exchangers with different coil pitches and curvature ratios were tested for both parallel-flow and counter-flow configurations. All the required parameters like inlet and outlet temperatures of tube-side and shell-side fluids, flow rate of fluids, etc. were measured using appropriate instruments. Overall heat transfer coefficients of the heat exchangers were calculated Hot water from hater flows inside the tube where it loses heat to cold water flowing through shell. The entry and exit of cold water in shell kept at top so shell should be filled completely and complete coil must be immersed in water. The flow of cold water is controlled by rotameter at the entry in shell, this cold water then carries heat to drainage. Hot water mass flow rate controlled after the exit of helical coil. This is done to get parallel flow and counter flow configurations. Four thermocouples are used to note using Wilson plots. The inner Nusselt numbers were compared to the values existed in open literature.

Nasser Ghorbani, Hessam Taherian, Mofid Gorji, Hessam Mirgolbabaei [8], Have done an experimental investigation of the mixed convection heat transfer in a coil-in-shell heat exchanger is reported for various Reynolds and Rayleigh numbers, various tube-to-coil diameter ratios and dimensionless coil pitch. The purpose of this article is to check the influence of the tube diameter, coil pitch, shell-side and tube-side mass flow rate over the performance coefficient and modified effectiveness of vertical helical coiled tube heat exchangers. The calculations have been performed for the steady-state and the experiments were conducted for both laminar and turbulent flow inside coil. It was found that the mass flow rate of tube-side to shell-side ratio was effective on the axial temperature profiles of heat exchanger -Nian Chen, Ji-Tian Han, Tien-Chien Jen





A ***B***

A.Figure 1: Basic geometry of simple helical pipe.
B.Figure 2: Basic geometry of a cone shaped helical pipe.

3.PROPOSED WORK

It is proposed to carry out "Experimentation thermal performance analysis of simple helical coiled concentric tube heat exchanger,Cone shaped and simple tube heat exchanger " For this dissertation work; the proposed work is divided into the following phases.

Phase I: Review of Literature: Detailed information of existing helical coil heat exchanger and simple tube heat excahnger

Phase II: Design and analysis of simple helical coil concentric tube and cone shaped helical coil tube heat exchanger.

Phase III: Fabrication of experimental set-up.

Phase IV: Testing of variuous parameters on experimental set up by using different shape of helical coil heat exchanger.
Phase V: Comparison of result obtained from different shapes. The Experimental data collected for simple tubeto tube,helical coiled tube and cone shaped coiled tube heat exchanger.
Phase V: carried out CFD analysis of the experiment through CFD code Fluent 6.3.
Phase VI: Comparison of Experimental results obtained from each shaped of coiled with simple tube.
Phase VII: Completion of Project and prepare Project Report.

A. SCOPE

From the literature review it is seen that there is mostly scope for research work in the area of heat transfer it is proposed to carry out some theoretical, experimental and analytical studies on helical coiled heat transfer augmentation using various coiled shaped with diameter change and microfins used.

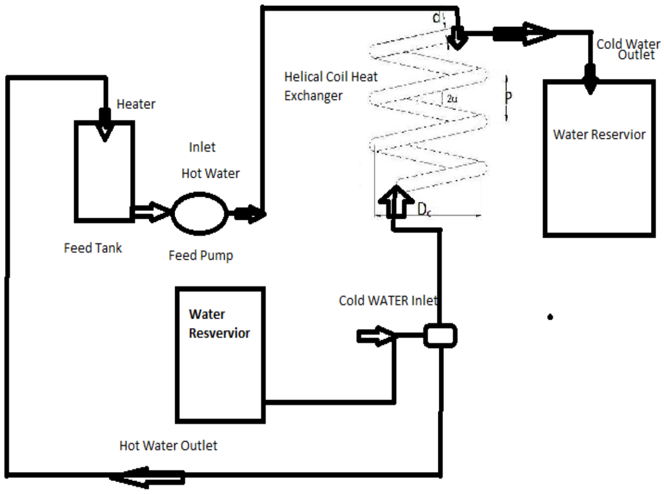
The use of helically coiled exchangers continues to increase. Applications include liquid heating/cooling, steam heaters, vapor-izers, cryogenic cooling and vent condensing

B. METHODOLOGY

Theoretical Analysis:

1. Determining detailed dimensions for helical coiled heat exchanger coiled diameter with given pitch variation as well as coiled inclination angle.
2. During experimentation pressured difference across the orifice meter, temperature of the cold water and hot water at inlet and outlet of the test section and Pressure drop across the test section are measured. The mass flow rate of fluid is determined from the pressure drop across the orifice meter, the useful heat gain of the fluid is calculated, and the Nusselt number is calculated.. Reynolds number based on hydraulic diameter is calculated.
3. Using the data obtained from experiments, the heat transfer coeff,Reynolds number,nusselt number,LMTD, friction factor and the thermal performance characteristics of fluid for different helical coiled are calculated. These calculated data is analyzed to find out increased heat transfer from various helical coiled shape.

C. PROPOSED EXPERIMENTAL SETUP:



4.CONCLUSION

From study it is clear that,

1) Comparative study between helical coil and straight tube to tube heat exchanger are studied.
2) Helical coil counter flow is most effective in all these conditions and straight tube parallel flow heat exchanger is least effective.
3) Overall heat transfer coefficient increases with increase in hot water mass flow rate and cold water mass flow rate.
4) The coil pitch is found to have significance only in the developing section of heat transfer. The torsional forces induced by the pitch causes oscillations in the Nusselt number.
5) Use of a helical coil heat exchanger was seen to increase the heat transfer coefficient compared to a similarly dimensioned straight tube heat exchanger.

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