IRJSE International Research Journal of Science & Engineering
Int. Res. J. of Science & Engineering, 2018; Special Issue A2 : 245-250
ISSN: 2322-0015
SJIF Impact Factor 4.11
UGC Approved Journal No. 63628
RESEARCH ARTICLE **OPEN ACCESS**

Design & Development of Tube in Tube Helical Coil Heat Exchanger

Patil Sateesha, Sanket Patel, Prashant Vavhal, Harshal Rahate

Mechanical Engineering Department, Savitribai Phule Pune University, Pune, MS, India,
Department of Engineering, P.K. Techanical Campus, Chakan (Pune), MS, India
Email: prashantvavhal44@gmail.com

Manuscript Details

Available online on http://www.irjse.in
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:
Patil Sateesha, Sanket Patel, Prashant Vavhal, Harshal Rahate.Design & Development of Tube in Tube Helical Coil Heat Exchanger , *Int. Res. Journal of Science & Engineering,* January 2018; Special Issue A2 : 245-250.

ABSTRACT

Conventional heat exchangers are large in size and heat transfer rate is also less. In conventional heat exchanger dead zone is produce which reduces the heat transfer rate. To create turbulence in conventional heat exchanger some external means is required. The fluid in conventional heat exchanger is not in continuous motion with each other. Tube in tube helical coil heat exchanger provides a compact shape with its geometry offering more fluid contact and eliminating the dead zone, increasing the turbulence and hence the heat transfer rate. An experimental setup is fabricated for the estimation of the heat transfer characteristics. A wire is wounded in the core to increase the turbulence in turn increases the heat transfer rate. The paper deals with the pitch variation of the internal wounded wire and its result on the heat transfer rate. The Reynolds number and Dean Number in the annulus compared to the numerical data. The experimental result compared with the analytical result which confirmed the validation. This heat exchanger finds its application mostly in food industries and waste heat recovery.

Keywords: Tube-in-tube, Nusselt number, wire wound, Reynolds number, Dean Number, dead zone

INTRODUCTION

Heat Exchanger is a device in which the exchange of energy takes place between two fluids at different temperature.

A heat exchanger utilizes the fact that, where ever there is a temperature difference, flow of energy occurs. So, That Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them. The energy flowing in a heat exchanger may be either sensible energy or latent heat of flowing fluids. The fluid which gives its energy is known as hot fluid. The fluid which receives energy is known as cold fluid. It is but obvious that, Temperature of hot fluid will decrease while the temperature of cold fluid will increase in heat exchanger.

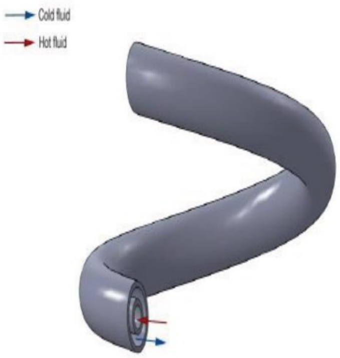

Fig. 1.1 Concept of Tube

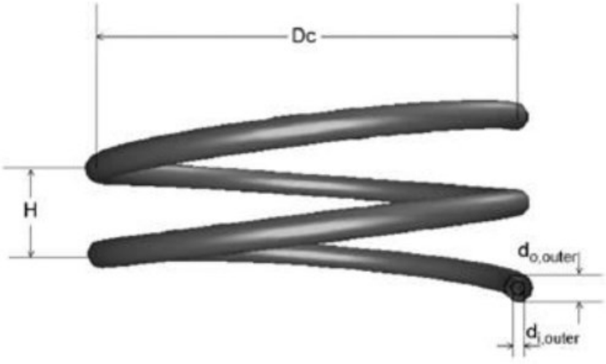

Fig. 1.2. Dimensional Representation of Tubein tube Helical Coil Hear exchanger

These types of heat exchanger are known as condensers or evaporators. Heat exchangers with the convective heat transfer of fluid inside the tubes are frequently used in many engineering application. The techniques of heat transfer enhancement to accommodate high heat flux i.e. to reduce size and cost of heat Exchangers have received serious attention passed years. Enhancement of heat transfer Rate in all types of thermo technical apparatus is of great significance for industry. Beside the savings of primary energy, it also leads to a reduction in size and weight. Up to the present, several heat transfer enhancement techniques have been developed.

The heat exchangers have an important role in the energy storage and recovery. Due to the development of modern technology, the heat exchangers required in various industries for high heat-flux cooling to the level of megawatt per meter square. At this level, cooling with conventional fluids such as water and ethylene glycol and so forth, are challenging. Hence, it is necessary to increase the heat transfer performance of working fluids in the heat transfer devices. Heat transfer augmentation techniques (passive, active and compound) are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. The rate of heat transfer can be increased passively by increasing the surface area, roughness, and by changing the boundary conditions. The active method involves addition of nano sized, high thermal conductivity and metallic powder to the base fluid, to increase the heat transfer rate. Such a fluid is termed as nano fluid. Where inserts are used in the flow passage to augment the heat transfer rate, are best suited compared to active techniques. Because the insert manufacturing process is simple and these techniques can be easily applied in an existing application. Shell-and-tube heat exchangers are the most common type of thermal equipment employed in chemical process industries. This widespread use can be justified by its versatility, robustness and reliability. Despite the technological advances of other exchanger types (e.g., plate-and-frame, spiral, lamella, etc.), shell-and-tube heat exchangers will maintain a central position in industrial.

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 development of secondary flows (flows perpendicular to the axial direction) which assist in mixing the fluid and enhance the heat transfer. In straight tube heat exchangers there is little mixing in the laminar flow regime, thus the application of curved tubes in laminar flow heat exchange processes can be highly beneficial. These situations can arise in the food processing industry for the heating and cooling of either highly viscous liquid food, such as pastes or purees, or for products that are sensitive to high shear stresses. Another advantage to using helical coils over straight. tubes is that the residence time spread is reduced, allowing helical coils to be used to reduce axial dispersion in tubular reactors. The first attempt has been made by Dean to describe mathematically the flow in a coiled tube. A first approximation of the steady motion of incompressible fluid flowing through a coiled pipe with a circular cross-section is considered in his analysis. It was observed that the reduction in the rate of flow due to curvature depends on a single variable, K, which is for low velocities and small It was then continued for the study of Dean for the laminar flow of fluids with different viscosities through curved pipes with different curvature ratios.The result shows that the on set of turbulence did not depend on the value of the Re or the De. It was concluded that the flow in curved pipes is more stable than flow in straight pipes. It was also studied the resistance to flow as a function of De and Re. There was no difference in flow resistance compared to a straight pipe for values of Deless than 14.6.

Rough estimates can be made using either constant heat flux or constant wall temperature from the literature. The study of fluid-to-fluid heat transfer for this arrangement needs further investigation. The second difficulty is in estimating the area of the coil surface available to heat transfer. As can be seen in Figure, a solid baffle is placed at the core of the heat exchanger. In this configuration the baffle is needed so that the fluid will not flow straight through the shell with minimal interaction with the coil. This baffle changes the flow velocity around the coil and it is expected that there would be possible dead-zones in the area between the coils where the fluid would not be flowing. The heat would then have to conduct through the fluid in these zones, reducing the heat transfer effectiveness on the outside of the coil. Additionally, the recommendation for the calculation of the outside heat transfer coefficient is based on the flow over a bank of no staggered circular tubes, which is another approximation to account for the complex geometry. Thus, the major drawbacks to this type of heat exchanger are the difficulty in predicting the heat transfer coefficients and the surface area available for heat transfer. These problems are brought on because of the lack of information in fluid-to-fluid helical heat exchangers and the poor predictability of the flow around the outside of the coil.

METHODOLOGY

PROBLEM STATEMENT

The objective of this work is to determine the heat transfer characteristics for a helical double-pipe heat exchanger by varying the flow rates of a single fluid in both the inner and outer tubes for counter flow and to compare the same with the double-pipe straight tube heat exchanger. Correlations between Nusselt number and Dean Number for the helical coiled heat exchanger are also developed. The problem is defined the flow and temperature contours of both the heat exchangers.

OBJECTIVE

Our prime objective is to study the performance of Helical Coil Tube in Tube heat exchanger compared to traditional heat exchanger, using an experimental setup. Further our project aim is studying the temperature drops in Helical coil Tube in Tube Heat Exchanger.

1. Design a helical double-pipe tube in tube helical coil heat exchanger.
2. Experimental analysis of a helical double-pipe tube in tube helical coil heat exchanger and Find out heat transfer rates, LMTD, overall heat transfer coefficient and Reynolds number, Nusselt number ,Dean number for counter flow arrangement.
3. Comparison of Experimental results of heliacal tube in tube heat exchanger to the traditional heat exchanger.

SCOPE

1. Heat transfer rate can be achieved at high amount in row spacing.

2. To reduce labor cost and labor time.
3. Reduce size of heat exchanger and increase the heat transfer rate.
4. Perform the various simultaneous operations and hence save the labor requirements.

Problem Identification

Heat exchanger is the process equipment designed for effective transfer of heat energy between two fluids; a hot fluid and coolant .Heat exchangers serve a straight forward purpose controlling a system’s or substance’s temperature by adding or removing thermal energy.

The main objective of this research is to determine the heat transfer characteristics of a helical heat exchanger, both numerically and experimentally, and to determine the effects of heat exchanger geometry and fluid properties on the heat transfer characteristics. To accomplish this goal, the following problems were encountered:

- Various parameters changing due to coil shape, temperature gradient and various Thermodynamic properties.
- Problems in determining overall heat transfer coefficient due to fouling, and other
- Parameters, Design and Construction of a physical model of the heat exchanger.
- Testing of the physical model under different flow rates and flow configurations.(Parallel flow and counter flow).
- Comparison of the results from both theoretical and experimental work.

CONSTRUCTION AND WORKING

Construction

This project, we study considering the double tube helical coil heat Exchanger or tube in tube helical coil heat exchanger with six (6) numbers of turns. For simplification in numerical analysis we consider only six turns but in practical problems it may be large number of turns depending on the requirements. The coil diameter (D) was varying from 80 mm to 240 mm in an interval of 40 mm that is 120 mm, 160 mm and 200 mm respectively. As the coil diameter increases the length of the exchanger (L) also increases. The inner tube diameter (d1) was 8mm.thethickness (t) of the tube was taken 0.5 mm. The outer tube diameter (d2) was taken 17mm.In this project we studying fixed the tube diameter (both inner and outer diameter) of the heat exchanger and vary the coil diameter of the tube to see the effect of curvature ratio (d/D) on heat transfer characteristics of a helical coil heat exchanger. The pitch of the coil was taken 30mm that is the total height of the tube was 315 mm.

The heat exchanger was made of STAINLESS STEEL. The fluid property was assumed to be constant for analysis. In this study we considered the counter flow heat exchanger as it has better heat transfer rate compared to parallel heat exchanger. The cold fluid and the hot fluid flow in opposite directions in their respective tube. In this study for analysis, turbulent fluid flow was considered. Both the hot fluid and cold fluid flow with a velocity, for which Reynolds number is greater than critical Reynolds number as per the correlation calculated by Schmidt. The flow velocity of cold fluid is remained constant and the hot fluid flow rate varied to find the heat transfer rate, friction factor and optimize the heat exchanger to have minimum pressure loss and maximum heat transfer. After creating the geometry on CATIA V5R18 and doing the drafting in AUTO CAD 2007 the 2D model was drawn on AUTO CAD (2007) for different manufacturing process as above mention method.

Working

A test run was completed on the apparatus. Once all of the components were in place, the system was checked thoroughly for leaks. After fixing the leaks, the apparatus was prepared for testing. The test run commenced with the apparatus being tested under laboratory conditions. Data was recorded every five minutes until the apparatus reached steady state. The hot temperatures fell as expected; the cold temperatures seemed to be more unpredictable in one instance rising six degrees in five minutes and then on the next reading falling three degrees. The apparatus took 120 minutes to reach steady state, which can vary based on operating conditions. Readings were taken until the three-hour mark;

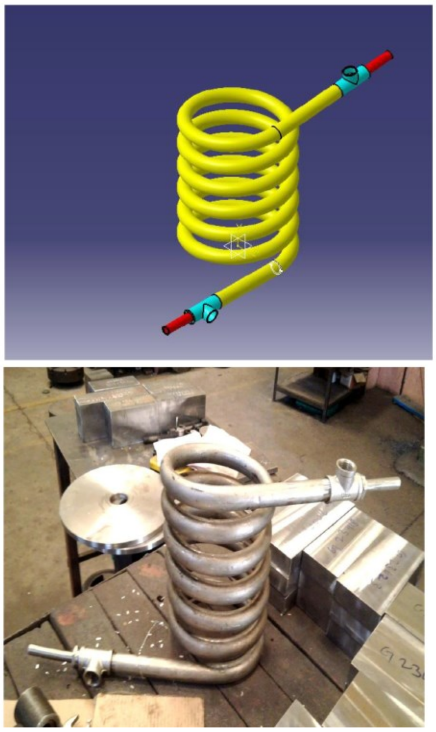

Fig.2 Assembly of TTHC Heat Exchanger

however, the data became inconsistent, so a steady state set was determined based on proximity of the readings. Flow rates in the annulus and in the inner tube varied. The following five levels were used: 100, 200,300, 400, and 500 LPH. All possible combinations of these flow rates in both the annulus and the inner tube were tested. These were done for all the coils in counter flow configurations. Furthermore, three replicates were carried out every combination of flow rate, coil size and configuration. This resulted in a total of 50 trials. Temperature data was recorded every ten seconds. The data used in the calculations was synthesized only after the system had stabilized. Temperature measurements from the 120 s of the stable system were used, with temperature reading fluctuations within ±1.10C. All the thermocouples were constructed from the same roll of thermocouple wire thus carried out for the repeatability of temperature readings being high.

ADVANTAGES AND APPLICATION

Advantage

1. Compact size provides a distinct benefit. Higher film coefficients the rate at which heat is transferred through a wall from one fluid to another and more effective use of available pressure drop result in efficient and less-expensive designs.
2. True counter-current flow fully utilizes available LMTD (logarithmic mean temperature difference). Helical geometry permits handling of high temperatures and extreme temperature differentials without high induced stresses or costly expansion joints.
3. High-pressure capability and the ability to fully clean the service-fluid flow are added to the exchanger's advantages.
4. Coils give better heat transfer performance, since they have lower wall resistance& higher process side coefficient.
5. A coil can provide a large surface area in a relatively small reactor volume.
6. High heat transfer rates.
7. Very close approach temperature - up to 2 °C
8. More compact due to increased overall heat transfer coefficient.
9. Suitable for high heat duty application.
10. Minimum cooling water requirement.
11. Suitable for low flow rates at high pressure / high temperature applications.
12. Maximum counters current efficiency.
13. Eliminates the tendency of dead spot formations.
14. Low pressure drop on outer tube side.
15. Rugged design, highly resistant to thermal and hydraulic shocks.
16. Easy to install.

APPLICATION

1. To cool process streams

- Gasoline product going to storage is cooled to reduce loosed because of its vapor pressure.
- General unit intercoolers remove the heat of reaction between reactors
- Absorber intercoolers on gas concentration units remove the heat of absorption and thereby increase the efficiency of the absorber.
- Fractionators condensers condense the overhead, part of which may be the product and the other part of which may be reflux that is returned to the column to help effect a separation.

2. To heat process streams
- Fractionator's re-boilers are used to add heat to fractionation column that effects a separation.
- Reactor charge heaters are used to heat the charge up to their action temperature.
3. To exchange heat between hot and cold process streams.
- Feed exchangers that are used to heat the reactor charge by exchanging heat with the reactor effluent.
- Fractionator's feed-bottoms exchanger that is used to heat the feed by exchanging heat with the bottoms.
4. Food industry
5. Textile industry
6. Pharmacy industry
7. Paper industry
8. Mostly used in give feed to the boiler

CONCLUSION

Various research works has been carried out in the past regarding to effectiveness of helical coiled heat exchanger and also form this experiment it is found that the helical coil heat exchanger may be a great option for effective heat transfer between two fluids in the modern industries where it may incorporated in the place of straight tube heat exchanger. Heat transfer is going to be very well along the heat exchanger. Fluid flow will become completely turbulent. Especial shape of the heat exchanger and secondary flows lead to random movement of the fluid particles in all directions so that axial, radial, and swirly movements exist together that mix the fluid very well and force the flow to be turbulent. Nusselt number magnitude is higher in the entrances because of the more temperature difference but it decreases as fluids go forward through the heat exchanger toward the exit points and as the temperature difference decreases.

Conflicts of interest: The authors stated that no conflicts of interest.

REFERENCES

1. Gavade Pravin P, Kulkarni P.R 'Experimental Evaluation of Helical Coil Tube in Tube Heat Exchanger" International Journal of Emerging Engineering Research and Technology Volume 3, Issue 2, PP 12-17.
2. Desai1 Vijay P, Borse Sachin L (2013),"Experimental Study on Enhancement Of Thermal Performance of Wire Wound Tube In Tube Helical Coil Heat Exchanger" International Journal of Engineering Research and Applications (IJERA) Vol. 3, Issue 4,,2013, 340-346.
3. Kshirsagar Mrunal P, Kansara Trupti J,Aher Swapnil M "Fabrication and Analysis of Tube-In-Tube Helical Coil Heat Exchanger" International Journal of Engineering Research and General Science Volume 2, Issue 3
4. Kumar Vimal, Faizee Burhanuddin, Mridha Monisha, Nigam KDP "Numerical studies of a tube-in-tube helically coiled heat exchanger" Sciencedirect Department of Chemical Engineering, Indian Institute of Technology, Delhi, HauzKhas, New Delhi-110016.
5. Hingane Pariksheet, KanasePatil AB "Design-Fabrication and Testing of Helical Tube in Tube Heat Exchanger" International Engineering Research Journal (IERJ) Special Issue Page 1245-1248, ISSN 2395-1621.
6. Gavade PP, Malgave SS, Patil DD, Bhore HS, Wadkar VV "Analysis of tube in tube helical coil & straight tube heat exchanger" Journal of Mechanical Engineering and Technology (JMET) Volume 3, Issue 2