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Research Article

A Review on Performance Prediction of Helical Coil Heat Exchanger

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Abstract

This paper deals with the review on performance improvement of the helical coiled tube with parallel and counter flow configuration of various correlations with specific data. The readings of mass flow rate and temperature difference of hot water fluid are recorded. Logarithmic Mean Temperature Difference LMTD, capacity ratio, universal heat transfer coefficient and effectiveness are calculated and compared for Parallel flow and Counter flow configuration with variations of coil configurations. By taking the reference of designing helical coil tubes will design the double pipe helical coils and experimental set up also has to prepare as per TEMA guidelines. The increased in the intensity of secondary's flow developed due to centrifugal force due to curvature of the pipes.

Keywords: *Coil Configurations, Flow configurations, , Heat transfer coefficient , Helical coil heat exchanger.*

1. Introduction

The important part of this paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. Each section may be provided to understand easily about the paper. The heat exchanger is a device which is used to transfer heat from one medium to another medium with efficient heat transfer rate. Fundamental of heat exchanger principle is to facilitate an efficient heat flow from hot fluid to cold fluid. In heat exchanger is a direct function of the temperature difference between the two fluids, the surface area where heat is transferred, and the conductivity of the fluid and the flow configurations. This basic relationship of overall heat transfer coefficient, which given by Equation:

$$Q = U_o A_{Sr} \Delta T_{LMTD} \quad (1)$$

Some of the researchers research on the curved tubes they found that helical coil tubes are having high heat transfer rate as compare to straight tubes heat exchanger. The several studies have indicated on the helical tubes are superior to straight tubes when employed in heat transfer rate. The secondary flow development due to centrifugal force in the curvature of the tubes. Typically, fluid in the core of the tube moves towards the outer wall, then returns to the inner portion of tube by flowing back along the wall, as shown in figure-1.

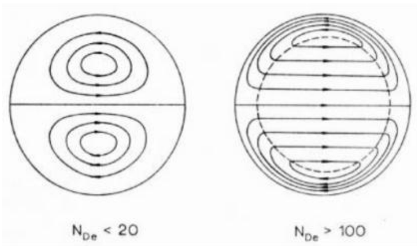

Figure-1: Secondary flow for low and high Dean Number

Secondary flow can be expected to enhance heat transfer between the tube wall and the flowing fluid. 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. Thus, for design of heat exchangers that contain curved tubes, or helically coiled heat exchangers, the heat transfer and hydrodynamic characteristics need to be known for different configurations of the coil, including the ratio of tube radius to coil radius, pitch, and Reynolds and Prandtl numbers and Dean Number (De).

Eustice in 1911 had first observed in the fluid motion in curved pipes. Then after numerous studies have been worked on the flow fields that arise in curved pipes (Dean,1927, 1928; White, 1929; Hawthorne, 1951; Horlock, 1956; Barua, 1962; Austin and Seader, 1973) including helical coils. The flow fields of helical coil tubes have been observed experimentally and numerically.

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The next logical step in observing the flow patterns was to study the patterns in heat transfer applications. Helical coil heat exchanger design is based on correlations between the Kern method and Bell-Delaware method.

- In Bell-Delaware method is based on the heat-transfer coefficient and pressure drop are estimated from correlations for flow over ideal pipes, and the effects of leakage, bypassing and flow of fluid in the pipe zone are allowed for by applying correction factors.
- In Kern's method-is based on experimental work on commercial exchangers with standard tolerances and will give a reasonably satisfactory prediction of the heat-transfer coefficient for standard designs. The prediction of pressure drop is less satisfactory, as pressure drop is more affected by leakage and bypassing than heat transfer.

2. Lecturer Review

In recent past year, the improvements in computing power have increased the interest of engineers and researchers to simulate their problems with computational and numerical methods. A lot of computational tools and methods have been developed in the last decades to analyses fluid dynamics, combustion, and different modes of heat transfer. Use of heat exchangers in wide range of applications attracts the researchers and scientists to work in this field. Some of the literatures are as follows;

Rahul Kharat et. al.(2009) has analyzed the heat transfer coefficient correlation for concentric helical coil heat exchanger. Their result is based on coil configuration. It was observed that the heat transfer coefficient decreases with the increase in gap. The heat transfer coefficient increases with the increase in tube diameter. This is due to reduction in coil gap with increasing tube diameter and the effect of tube diameter is not dissociated with the effect of coil gap.

Jayakumar and Grover *et al*. (1997) had investigated the performance of residual heat removal system for two phase natural circulation. They had done their experiments on helical coil heat exchanger. They had studied the effect of different process parameter on heat transfer characteristics.

Kapil Dev *et al*(2014) has carried out an empirical study of helical coil heat exchanger used in liquid evaporization and droplet disengagement for a laminar fluid flow. They focused on design parameters and heat transfer conditions of a generator of a simple vapors absorption refrigeration system with flow condition of refrigerant taken as laminar flow. If the required design parameters would be changed, then the effectiveness of heat exchanger remains same by increasing the surface area of helical coils. It is also found that the heat transfer coefficient could be increased with the mass flow rate.

Pablo Coronel *et al*(2008) has carried out experiments to study heat transfer coefficient in helical heat exchanger under flow conditions. His study involved the determination of convective heat transfer coefficient in both helical and straight tubular heat exchangers under turbulent flow conditions.

Experiments were conducted in helical heat exchangers, with coils of two different curvature ratios (d/D = 0.114 and 0.078), and in straight tubular heat exchangers at various flow rates (0.000189 - 0.000631 m^3/s) and for different end-point temperatures (92 - 149°C). The results show that the overall heat transfer coefficient (U) in the helical heat exchanger is much higher than that in straight tubular heat exchangers. The inside (hi) and outside (ho) convective heat transfer coefficients were determined based on the overall heat transfer coefficient and a correlation to compute the inside convective heat transfer coefficient (hi) as a function of NRe, NPr, and d/D (dean number) was developed.

Timothy J. Rennie*et al*(2005) has carried out experimental studies of a double-pipe helical heat exchanger using two differently size heat exchanger. It was observed that there were little differences in overall heat transfer coefficient between parallel and counter flow configurations with two different inner coil diameters. Heat transfer rates were found much higher in counter flow configuration than in parallel one. Nusselt number in the inner tube was compared with literature values and found to be in good agreement.

B. ChinnaAnkanna et.al.(2014) has carried out a performance analysis of fabricated helical coil heat exchanger. He investigated the effect of various parameters that affect the effectiveness of a heat exchanger like number of coils, flow rate and temperature. After conducting the experiments and comparing the results obtained on helical (Parallel and counter flow) and straight (parallel and counter flow) tube, the following results are drawn:

- The helical pipe is having the greater surface area which allows the fluid to be in contact for greater period of time period so that that there is an enhanced heat transfer compared to that of straight pipe.
- The inside over all heat transfer coefficient for helical pipe is approximately 0.35 of that straight pipes.
- The temperature of cold water coming from the helical tube in counter flow arrangement is (38°C - 52 °C) i.e. a rise in the temperature of water is between 7°C to 21°C.It implies that for the same surrounding area the helical pipe absorbed is more than that of straight copper tube.
- The effectiveness of pipes either helical or straight in counter flow is greater than parallel configuration.
- From the above one can realize the fact that for the same space or volume in industry the helical heat

exchangers are more efficient than normal straight heat exchangers.

- The influencing parameters on effectiveness and overall heat transfer coefficient in the decreasing order are: Flow rate, Hot water inlet temperature and number of turns.

Study on the flow and heat transfer characteristics in a spiral-coil tube had done by Naphon (2011). He did both the numerical and experimental study on a horizontal spiral-coil tube to predict the flow characteristic. The standard k–ε two-equation turbulence model was used to simulate the turbulent flow and heat transfer characteristics of the fluid. The heat transfer rate or heat transfer coefficient had affected by the centrifugal force. However, the pressure drop also increases. He found that the Nusselt number and pressure drop obtained from the spiral-coil tube are almost one and half times higher than that of the straight tube due to the centrifugal force.

H. S. Patel *et al* (2013)carried out a review on the performance evaluation and CFD analysis of double pipe heat exchanger. They described the different techniques which may help to enhance the heat transfer rate. Heat exchangers are modified in space of annular, also using Nano particle in water and compared with the conventional heat exchanger. Results shows that heat transfer rate of modified heat exchanger are higher than the conventional heat exchanger. Nano particles dispersed in water can significantly enhance heat transfer rate and also heat transfer rate increase with increase of mass flow rate. It may conclude that heat transfer augmentation techniques are successful to increase heat transfer performance of double pipe heat exchanger.

AlokVyas *et al* (2013) has studied the various experimental research work on performance of tubular heat exchangers. The tubular heat exchanger is used throughout various industries because of its inexpensive cost and handiness when it comes to maintenance. Their study was focused on tube diameter, tube length, number of tubes, number of baffles,& baffles inclination. They concluded that heat transfer coefficients coming out by use of 30° baffles are more efficient than 0° baffles.

S. Laohalertdecha*et al*(2012) studied the heat transfer performance and pressure drop characteristics of various enhanced tube. It was found that different types of the enhanced tubes (corrugated tube, ribbed tube, grooved tube and fluted tube) have great potential for heat-transfer enhancement and are highly suited to applications in practical heat-transfer processes.

Pardeep Kumar *et al*(2014) carried out an experimental investigation to study the Heat transfer Enhancement of Helix-changer with Grooved Tube. It was found that results of heat transfer enhancement of helix changer assisted by grooved tubes over plain tubes at same operating conditions, heat transfer enhancement by using grooves on tubes, which is a passive heat enhancement technique, is still far from the practical application with helix baffle. The groove pattern on tubes will increase turbulence, degree of movement of fluid which leads to better heat enhancement over the plain tube helix-changer.

Conclusion

After reviewing on literature some of the conclusions are as follows;

1) From the literature only some modification had developed in coil configuration, so can work modification on coil configuration for increases heat transfer coefficient.
2) Work on Nano fluid in helical coil heat exchanger with different density of the working fluid.
3) The optimize this condition based on effect of dean number for all trials and also effect on Nusselt number in both flow conditions (parallel flow and counter flow) are not found out yet.

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