A Review on Analysis of Helical Coil Heat Exchanger with Baffles by Numerical Simulation

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Abstract

In the present review the analysis on the helical coil heat exchangers is done by ansys fluent. Its main aim is to study the effect of providing baffles on the helical coil heat exchangers. For study, a three dimensional helical double tube heat exchanger is considered; baffles are provided in annular space between these two tubes. The geometry is modelled using ansys design modular. The analysis is done on counter flow configuration with different thickness of baffles and different curvature ratio (D/d). Also we considered laminar and turbulent case for study. The variation of Nusslet number with different Reynold number and with different baffle thickness is plotted. It is found by study that on increasing the baffle thickness up to a certain limit Nusselt number increases, also it is found that on increasing curvature ratio Nusselt number decreases.

Keywords: Helical coil heat exchanger, Baffles, Nusselt number, Reynold number, D/d Ratio

I. INTRODUCTION

A. Heat Exchangers:

Heat exchanger is a device which is used to transfer heat between different fluids which is at different temperatures, which may be in contact directly or may be flowing separately. Numerous applications of heat exchangers can be observed in our day today life, like condensers and evaporators used in refrigerators and air conditioners and in case of thermal power plant condensers, boilers, air coolers and cooling towers are used as heat exchangers.

B. Helical Coil Heat Exchangers:

Enhancing the heat transfer by the use of helical coils has been studied and researched by many researchers, because the fluid dynamics inside the pipes of a helical coil heat exchanger offer certain advantages over the straight tubes, shell and tube type heat exchanger, in terms of better heat transfer coefficients

1) Advantages of Helical Coils:

- Surface area for heat transfer is large.
- Heat transfer rate of helical coil is larger than straight tube heat exchanger.
- It has a compact structure and it requires less floor area than other heat exchangers.
- Self-cleaning.

2) Baffles:

- Baffles are flow directing or obstructing vanes used in heat exchangers to direct the flow of fluids.
- Baffles are also used to produce turbulence in flow
- It also helps to maintain two coils concentric.

II. LITERATURE REVIEW

1) Naphon et al.(2005) has studied heat transfer characteristics of spiral coil heat exchanger which is subjected to wet-surface conditions, they have done both experimental and numerical studies to find out heat transfer rate as well as to predict spiral coil heat exchangers performance. For the analysis they used cooling and dehumidifying condition. The result that they got suggests that rate of mass flow and temperature of inlet air affects temperature of water and air at the outlet. The outlet temperature of air and water decrease with increase in water mass flow rate. With increase in mass flow rate of air and water rates the humidity effectiveness and enthalpy decrease.
2) Eiamsa-ardet al. (2005) studied the Enhancement of the heat transfer by introducing helical tapes for straight tube. Experimentally they found that helical tape inserts in the inner tube of heat exchanger enhances the heat transfer rate by introducing swirl motion and the swirl motion induced will increase the turbulence and there by heat transfer.
3) Rennie et al. (2006) has done numerical analysis of double-pipe helical heat exchanger .The heat exchanger was numerically investigated for laminar flow conditions for both parallel flow and counter flow configuration and heat transfer rate for

different flow rates and tube size was also looked upon. The correlation between annulus Nusselt numbers and a modified Dean number was found.

4) Kumar et al. (2006) investigated heat transfer characteristics and hydrodynamics of tube in tube helical coil heat exchanger the experimental work was done on counter flow setup of heat exchanger and overall heat transfer coefficients was evaluated. The Nusselt number and friction coefficient for outer tube as well as inner tube was calculated and then it is compared with numerical values got from CFD software package FLUENT. The observation made by them is that overall heat transfer coefficient increase with inner coil dean number for constant flow rate in annulus region.
5) Kharat et al. (2009) has done experiment on concentric helical coil heat exchanger to study the heat transfer rate and develop the heat transfer coefficient correlations. The effect of various operating variables like diameter of tube, gap between the concentric coils and coil diameter. The gap between concentric coils and tube diameter affects the heat transfer coefficients and results obtained by them suggests that with increase in coil gap results in the decrease of heat transfer coefficient and when tube diameter increase the heat transfer coefficient increases.
6) Huminic et al.(2011) has done numerical investigation on double tube helical coil heat exchangers heat transfer characteristics. Working fluid consider for heat exchanger was Nano fluids. CuO and TiO2 where used as Nano particles in the working fluid. They consider laminar flow condition in the heat exchanger. They suggested that concentration of Nano particle and Dean Number a function of curvature ratio affects the heat transfer rate and heat transfer coefficient in helical coil heat exchanger respectively and with the increase in Dean number the rate of heat transfer increases
7) Jahanmir et al. (2012) has done numerical investigation on shell and tube heat exchanger having single twisted tube bundle for five different twist angles and then compared the result obtained with the conventional shell and tube heat exchanger with single segmental baffles. The effect of shell side nozzles configuration on heat exchanger performance was also studied. The analysis of results explains that for same shell side flow rate, the heat transfer coefficient of heat exchanger with twisted tube bundle is lower than that of heat exchanger with segmental baffle. Heat exchanger shell side pressure drop with twisted tube bundle is also much lower compared to that of heat exchanger with segmental baffles. For heat exchanger with twisted tube bundle pressure drop reduces rapidly compared to that of single segmental baffle heat exchanger. In the range of 25o – 65o twist angle the overall heat transfer coefficient and pressure drop was negligible. The maximum heat transfer rate for a given Pressure drop was corresponding to angles 55o and 65o
8) Jamshidi et al. (2013) has experimental work on shell and helical tube heat exchanger to enhance heat transfer in helical tube section hot water is flowing and cold water is flowing on the shell side. The determination of heat transfer coefficient was done using Wilson plots. Taguchi method was used to optimise the coil diameter, pitch of the coil and shell side flow rate. He found out that coil diameter of helical coil, coil pitch and tube side flow rate are the most relevant parameters in helical coil heat exchangers. From the experimental works it was found that coil pitch affect the Nusselt number and this caused due to fluid flow rate. The high value for tube side Nusselt number is obtained for lowest coil pitch and high tube side flow rate this is caused due to higher torsion occurring for lower pitches. With the decrease in coil pitch the curvature of tube increases and strong secondary flow is produced in tube side which enhances the heat transfer. The tube side Nusselt number and overall heat transfer coefficient increases with increase in coil diameter of the tube. After extensive literature review it has been found that although many work has been done on helical coil heat exchanger without baffle to find out the heat transfer coefficient and effect of curvature ratio and pitch of the coil no work has been done comparing Nusselt number for Helical coil with baffle and without baffle.
9) Lu et al. (2014) has done both numerical and experimental work on shell-side thermal hydraulic performance of multilayer spiral wound heat exchangers subjected to different thermal boundary conditions for the wall.

III. CONCLUSION

Numerical simulation of helical coil tube in tube heat exchanger has been done with Ansys fluent and the variation of Nusselt number with different baffle thickness and for various D/d ratio and different flow rate of hot fluid has been plotted. The conclusion drawn as follow-

- With increase in D/d ratio the Nusselt number is decreasing, this is due to the effect of centrifugal force which is more for small D/d ratios and for high D/d ratio the behavior of helical coil tends to that of straight tube.
- For Laminar flow for different D/d ratios the Nu variations with Re follow the same pattern.
- By increasing the thickness of baffles up to certain limit value of Nu increases, after which on increasing thickness of baffles Nu decreases this occurs due to reduction in area for convection.

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