International Journal of Advanced Technology in Engineering and Science
Vol. No.08, Issue No. 09, September 2020
www.ijates.com
ijates
ISSN 2348 - 7550

"COMPARISON OF STRAIGHT TUBE AND HELICAL COIL SHELL AND TUBE HEAT EXCHANGER PERFORMANCE USING CFD ANALYSIS"

Vivek Singh Parihar[1], Dr. Shrikant Pandey[2],

Dr. Rakesh Kumar Malviya[3], Mr. Palash Goyal[4]

[1,2,3,4] *Mechanical Engineering Department of, SVITS, SVVV, Indore, India*
(*viveksinghparihar27@gmail.com*)

Abstract

The aim of this work is to design of shell and tube type heat exchanger with a straight tube and a helical tube and comparing both of its performance based on the flow and temperature field inside the shell using ANSYS software tools. Straight tube heat exchanger is the most common type heat exchanger widely used in industries, but the Helical Coil Heat Exchanger is also widely used in industrial applications because it can accommodate greater heat transfer area in a less space. All the models are design by using SOLIDWORK 2017 software tools. In this paper how temperature field inside the shell varies at constant flow rate has been studied to prove that model-II (Helical Coil Heat Exchanger) is better than model-I (Straight tube heat exchanger). The analysis has shown that the model-II is 23.7% more efficient than model-I.

Keywords – Heat transfer, Shell and Tube heat exchanger, CFD Analysis.

I. INTRODUCTION

Heat exchangers are used in engineering fields. There are many types of heat exchangers are available according to their application (Gugulothu et al., 2019; Stehlik et al., 1994). [1]Besides the performance of the heat exchanger being improved, 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. Helically coiled tubes have been introduced as one of the passive heat transfer enhancement techniques due to their compact structure and high heat transfer coefficient. Prabhanjan, G. S. V. Ragbavan and T. J. Kennic [2] Have done experimental study to determine the relative advantage of using a helically coiled heat exchanger against a straight tube heat exchanger. All tests were performed in the transitional and turbulent regimes.Rahul Kharat, Nitin Bhardwaj, R.S. Jha [3] Mathematical model is developed to analyze the data obtained from CFD and experimental results to improved heat transfer coefficient correlation for the flue gas side of heat exchanger.Yang et al. (2016) [4] studied about combined serial two shell-pass shell-and-tube heat exchanger (CSTSP-STHXs) with continuous helical baffle and improved the heat transfer performance. Wang et al. (2009) [5] conclude that blocking the gap between the baffle plates and shell by use of sealer which effectively decreases the short-circuit flow in the shell-side and overall heat transfer coefficient heat transfer increased by 15.6–19.7%. Taher et al. (2012) [6] is tested the effect of baffle space in different cases on heat transfer of exchanger. Abd et al. (2018) [7] investigated the effect of shell diameter and tube length on heat transfer coeffcient and pressure drop for shell side with both triangular and square pitches and also studied the effect of baffle spacing and cutting space on heat transfer coefficient and pressure drop.

The purpose of this work is to determine the relative 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 at constant flow rate due to their shape. Due to the curvature of the tube induces centrifugal forces which act on the moving fluid results in the development of secondary flow therefore the fluid streams in the outer side of the pipe moves faster than the fluid streams in the inner side of the pipe.

II. METHODOLOGY

In this research, the model of the heat exchanger is designed on CAD software SOLIDWORKS 2017 and the simulation of that heat exchanger had done in ANSYS 18. The detailed of the methodology adopted for this study has been shown in fig. 1.

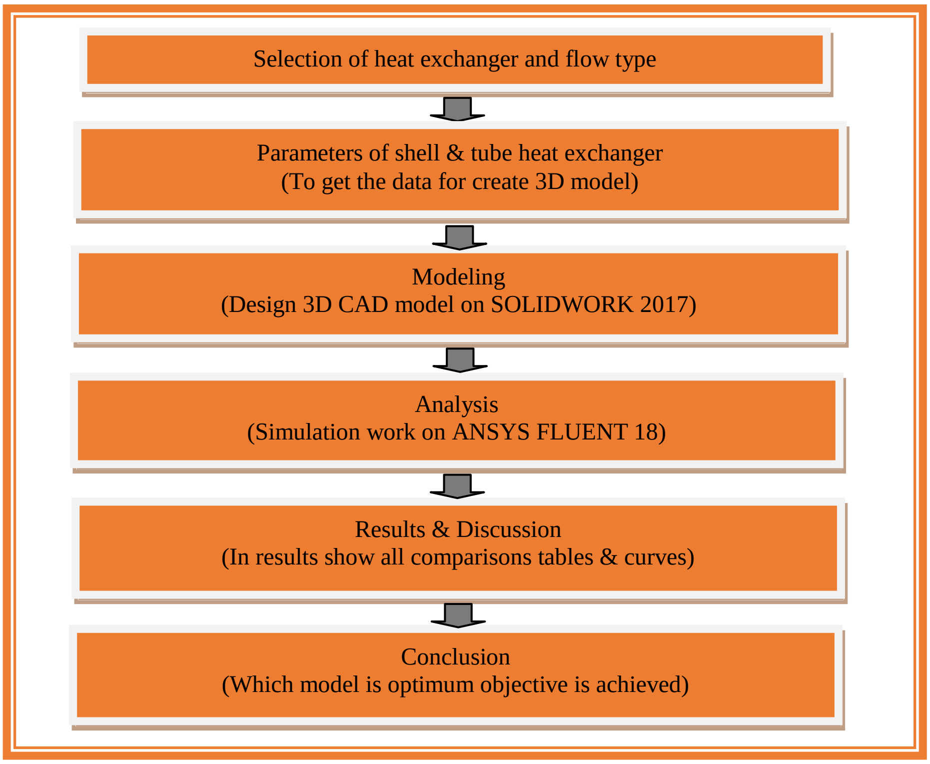


Fig. 1 Methodology adopted for the study

III. RESULTS

From the CFD analysis the following results were obtained-

A) Design parameters of straight tube and helical coil heat exchanger

ijates
ISSN 2348 - 7550

TABLE I
DESIGN PARAMETERS OF CONVENTIONAL HEAT EXCHANGER

S.No	Parameter	Dimension
1	Shell diameter	0.091m
2	Shell length	0.52m
3	Shell thickness	0.003m
4	Tube diameter	0.013m
5	Tube length	0.52m
6	Tube thickness	0.001m
8	Tube pitch	0.035m
7	Tube pitch type	Rectangular pitch
8	Number of tubes required	4
9	Number of turns in helical coil	3 turns
10	Shell inlet diameter	0.02m
11	Shell outlet diameter	0.02m

MODEL-I Straight tube shell and tube heat exchanger without baffle-

Side view-

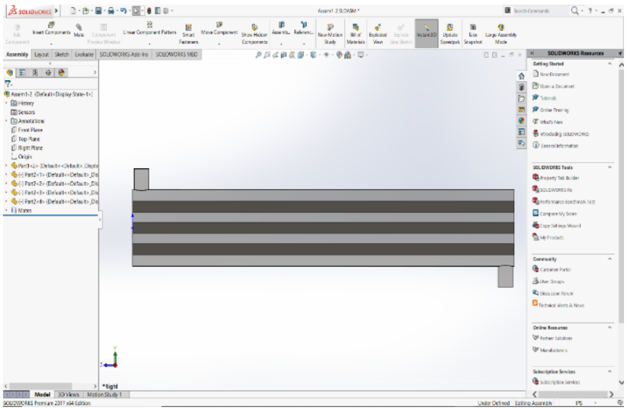


Fig.2 Side view of straight tube STHXs

Isometric view-

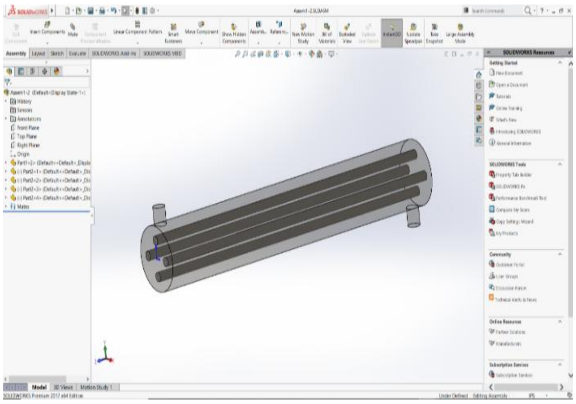


Fig.3 Isometric view of straight tube STHXs

MODEL-II Helical coil shell and tube heat exchange without baffles-

Side view-

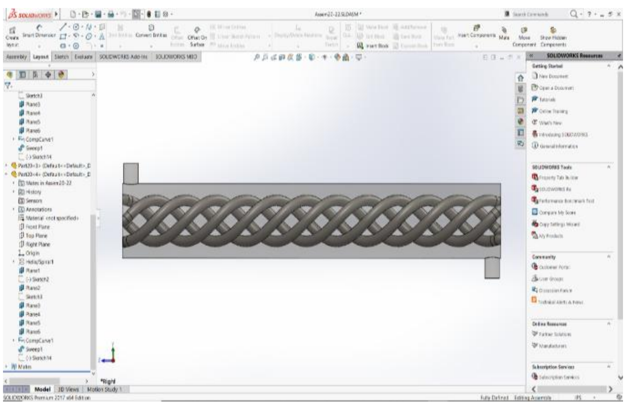


Fig.4 Side view of a helical coil without baffles STHXs

Isometric view-

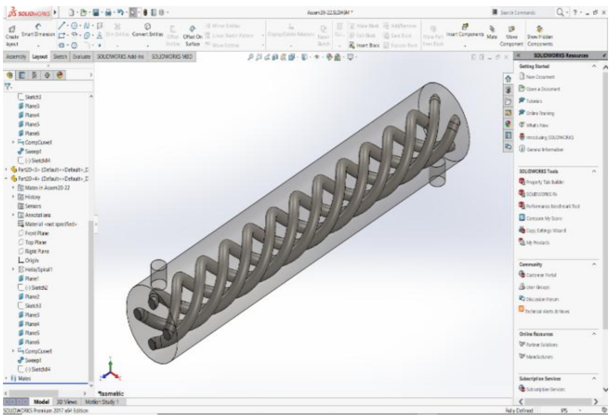


Fig.5 Internal view of a helicalcoil without baffles STHXs

International Journal of Advanced Technology in Engineering and Science
Vol. No.08, Issue No. 09, September 2020
www.ijates.com
ijates
ISSN 2348 - 7550

B. Data input for analysis of heat exchanger

TABLE II DATA INPUT FOR ANALYSIS OF HEAT EXCHANGER

Fluid type	**Water fluid**
Flow type	Counter flow
Inlet temperature of hot fluid	90˚C
Inlet velocity of hot fluid	0.3m/s
Inlet temperature of cold fluid	26˚C
Inlet velocity of cold fluid	0.7m/s
Initialization	Standard
Run calculation	15-time steps, 25 iteration steps
Environmental Condition	27˚C, 1 atm

MODEL-I Straight tube shell and tube heat exchanger without baffle-

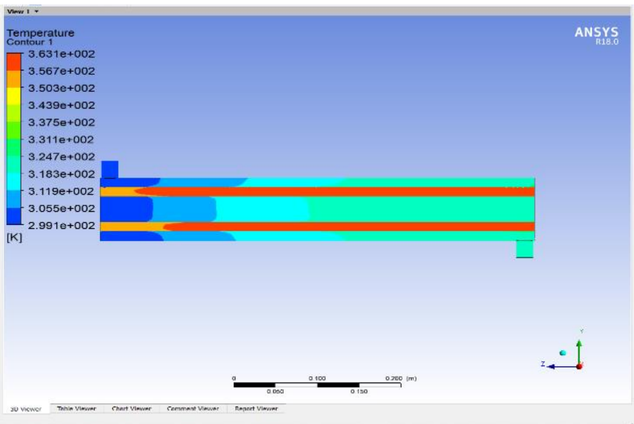
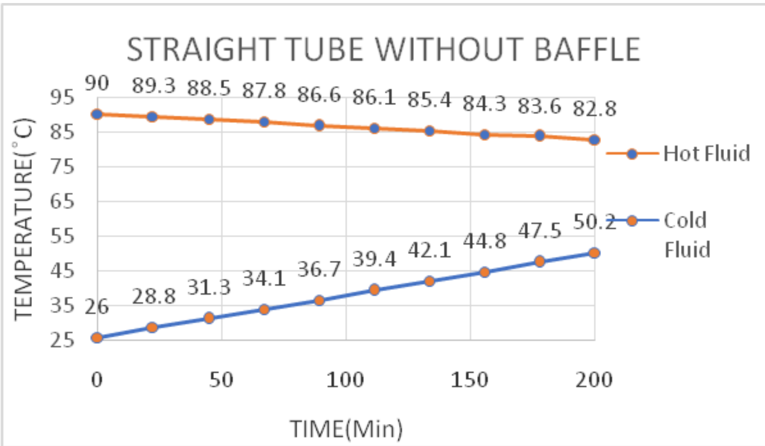


Fig.6 Temperature view of straight tube STHXs

Static Temperature	(k)
hot_inlet	363.14999
hot_outlet	355.94843

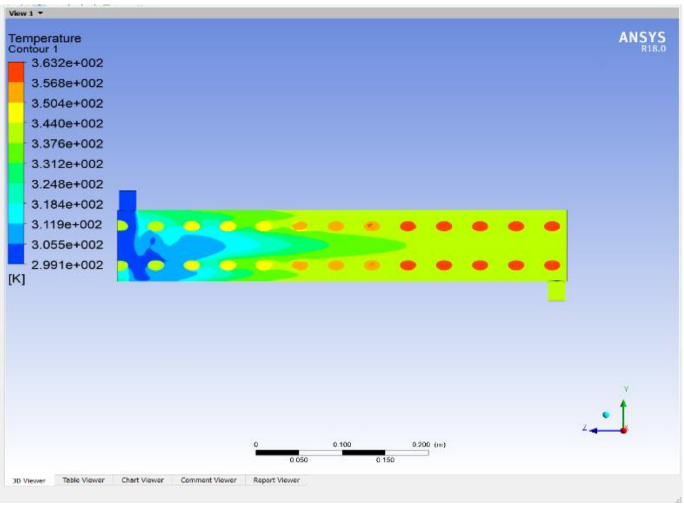
Temperature curve of both fluids-



Static Temperature	(k)
cold_inlet	299.14999
cold_outlet	323.37307

Fig.7 Straight tube without baffle curve

MODEL-II Helical tube shell and tube heat exchanger without baffles-



Static Temperature	(k)
hot_inlet	363.14999
hot_outlet	340.7629

Fig.8 Temperature view of helical tube without baffles STHXs

Temperature curve of both fluids-

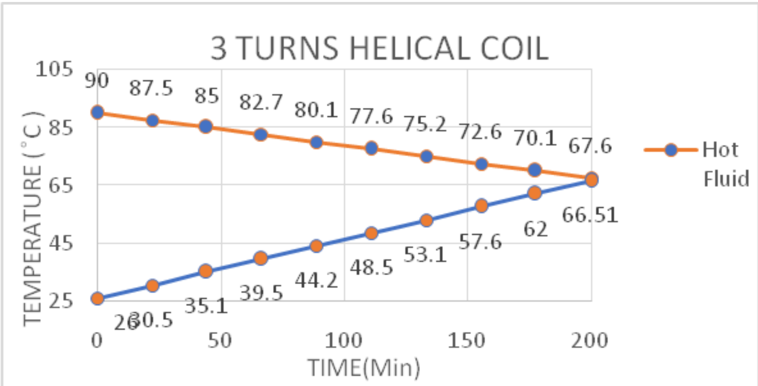


Fig.9 Straight tube with 7 baffles curve

Static Temperature	(k)
cold_inlet	299.14999
cold_outlet	339.66406

IV. DISCUSSION

In conventional type straight tube heat exchanger show that the temperature difference between hot water inlet to hot water outlet is 7.2° C and cold-water inlet and outlet temperature difference is 24.2° C. In helical tube heat exchanger seen that the temperature difference between hot water inlet and outlet is 22.4° C and cold-water inlet, and outlet temperature difference is 40.5° C. Here is the comparison table III-

V. CONCLUSION

The objective of the study is to enhance the performance of straight shell and tube heat exchanger by using helical tube in shell and tube heat exchanger. The CAD software namely SOLIDWORKS 2017 and analysis software namely ANSYS FLUENT 18 are used for achieving the objective of the research. In model- II helical tube shell and tube heat exchanger have temperature differences which is more than that model-I heat exchanger. So, the performance of the heat exchanger increased using helical tube.

In future work, use different technique and smart material which forcefully extract heat from hot fluid to cold fluid.

REFERENCES

[1] Prabhanjan, D. G., Raghavan, G. S. V., & Rennie, T. J. (2002). Comparison of heat transfer rates between a straight tube heat exchanger and a helically coiled heat exchanger. *International communications in heat and mass transfer*, *29*(2), 185-191.

[2] Prasad, B., Shaban, M. K., Haneef, S., & Raj, V. (2013). Comparison of Heat Transfer between a Helical and Straight Tube Heat Exchanger. *International Journal of Engineering Research and Technology. ISSN*, 0974-3154.

[3] Rahul Kharat, Nitin Bhardwaj, R.S. Jha, 2009, Development of heat transfer coefficient correlation for concentric helical coil heat exchanger.

[4] Yang, J. F., Lin, Y. S., Ke, H. B., Zeng, M., & Wang, Q. W. (2016). Investigation on combined multiple shell-pass shell-and-tube heat exchanger with continuous helical baffles. Energy, 115, 1572-1579.

[5] Wang, S., Wen, J., & Li, Y. (2009). An experimental investigation of heat transfer enhancement for a shell-and-tube heat exchanger. Applied Thermal Engineering, 29(11-12), 2433-2438.

[6] Taher, F. N., Movassag, S. Z., Razmi, K., & Azar, R. T. (2012). Baffle space impact on the performance of helical baffle shell and tube heat exchangers. Applied Thermal Engineering, 44, 143-149.

[7] Abd, A. A., Kareem, M. Q., & Naji, S. Z. (2018). Performance analysis of shell and tube heat exchanger: Parametric study. Case studies in thermal engineering, 12, 563-568.

[8] Prabhanjan, D. G., Raghavan, G. S. V., & Rennie, T. J. (2002). Comparison of heat transfer rates between a straight tube heat exchanger and a helically coiled heat exchanger. *International communications in heat and mass transfer*, *29*(2), 185-191.

[9] Prasad, B., Shaban, M. K., Haneef, S., & Raj, V. (2013). Comparison of Heat Transfer between a Helical and Straight Tube Heat Exchanger. *International Journal of Engineering Research and Technology. ISSN*, 0974-3154.

[10] Genić, S. B., Jaćimović, B. M., Jarić, M. S., Budimir, N. J., &Dobrnjac, M. M. (2012). Research on the shell-side thermal performances of heat exchangers with helical tube coils. *International Journal of heat and mass transfer*, *55*(15-16), 4295-4300.

[11] Shirgire, N. D., & Kumar, P. V. (2013). Review on comparative study between helical coil and straight tube heat exchanger. *Journal of Mechanical and Civil Engineering*, *8*(2), 55-59.

[12] Prasad, V., Shaji, I., Ahmed, N., & Sivan, V. Performance comparison of a helical coil heat exchanger with a straight tube heat exchanger using ansys-fluent.