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Study on Effect of Twisted Tape Insert Geometry in Heat Exchanger

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ABSTRACT
The heat exchanger is a device used to transfer heat from hot fluid to cold fluid. The current research reviews existing work conducted in improving performance of heat exchanger by varying geometric profile, baffling space, baffling inclination and use of helical inserts. The existing researches were conducted using both experimental and numerical techniques. The effect of operational parameters on performance of heat exchanger is also presented.

KEYWORDS: *Heat Transfer, CFD, Helical insert*

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1. INTRODUCTION

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, naturalgas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant

2. LITERATURE REVIEW

B. Peng et al. [1] proposed two STHX with helical continuous baffles installed in them rather than segmental baffles. As the "overall pressure drop" was kept same the heat transfer coefficients from shell side for former baffles was higher than the later ones. The heat transfer coefficient for the continuous helical baffles is 10% more than the segmental baffles. The mean square deviation was less than 3.12% when correlation between Nu, Re and friction factor and Re was developed.

Gay et al. [2] determined heat transfer coefficients on shell side for a cylindrical STHX and described mass transfer electrochemical technique and its applications. Mercury evaporation technique was used to obtain the accuracy of electrochemical method by comparing heat and mass transfer data. This electrochemical method showed good results in determining heat transfer coefficient in STHX. Less error was found by this method.

D. Kral. Et. al.[3] experimentally verified the working of heat exchangers having helical baffles. Various baffle geometries were also discussed and results were put forward. Results showed that the optimum baffle angle should be kept from 20^0-40^0 for maximum performance and making heat exchanger a less economic. At helix angle of 40^0 the pumping power required was quite less as compare to other helix angles.

Edward et al.[4] presented a procedure to find shell sided pressure drop in STHX installed with segmental baffles. By virtue of this procedure gave the measurement of pressure drop in ideal tube bank using correlations and pressure drop through equations on a window section using Delaware method. Tube bank was coupled with correction factor and leakage and bypass stream was taken into account. Results showed the deviation between measured pressure (ΔPm) and calculated pressure (ΔPc) with increasing Re. The deviation, experimental and theoretical, was found between ± 35%. When bundle bypass factor and baffle leakage was low, pressure drop was reduced but simultaneously heat transfer decreased drastically.

Huadong li et al.[5] investigated the pressure drop and heat transfer on shell side of shell-and-tube heat exchanger installed with segmental baffles fitted at different spacing. Measurement of both parameters was doe per row, per tube and each compartment. It was achieved that at Re 5000 the increase in baffle space enhanced heat transfer coefficient. Flow velocity also reached higher values. Short baffle spacing showed less values of pressure drop compared to that of long baffle spacing.

S.Noie[6] used experimental and theoretical method in determining behaviour of shell side flow. Re and effect of different geometrical parameters were taken into consideration. Baffle spacing were taken as 0.20, 0.25, 0.33, 0.50. 0.66 and 1.0 times the inside diameter of the shell and baffle cuts were put as 16%, 20%, 25%, 34%, and 46% of baffle diameter. Results revealed that baffles had great impact on heat transfer and pressure drop. It was also found that baffle cuts have not much impact while number of baffles had a great effect on shell and tube heat exchangers performance. By varying Re heat transfer increased and Re can be varied using more baffles not by varying velocity as it will be costly.

Jayakumar et al. [7] The experiment done at the cold and hot water mass flow rates ranging between 0.10 and 0.22 kg/s, and between 0.02 and 0.12 kg/s, respectively. The inlet temperatures of cold and hot water are between 5 – 25^{0}C, and between 5 – 45^{0}C, respectively. The effects of the inlet conditions of both working fluids flowing through the test section on the heat transfer characteristics discussed[7].

Ghorbani et al. [8] was done an experimental investigation of the mixed convective heat transfer in a coil-in-shell heat exchanger for various values of Reynolds number and Rayleigh numbers. Helical coil tubes were made from 9.5mm and 12.5mm OD tube and pitch was 16.5 mm and 23.5mm.The purpose of this study was 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. Experiments were conducted for both laminar flow and turbulent flow inside coil using water as working fluid and Nusselt number calculations were performed assuming the steady state condition at different characteristics length to find out best characteristics length. From experimental result it was observed that tube diameter had negligible influence on shell side heat transfer coefficient for same pitch on other hand heat transfer coefficient increase with increase in curvature ratio. It was also reported that overall heat transfer coefficient increases with pitch and Nusselt number increases with Reynolds number and Rayleigh number After validation against previous literature it was found that equivalent diameter of shell is best characteristics length to correlate Nusselt number with Rayleigh number and Reynolds number.

Jayakumar et al. [9] was worked on CFD analysis of helical pipe by variation of local Nusselt number along the circumference and the length of tube. CFD simulations were carried out for vertically oriented helical coils tube by varying coil parameters such as tube dia. 20, 30 and 40mm, pitch of coils were 0,15,30,45 and 60 mm and for twelve different configurations. It had been found that local variation of heat transfer in outer side of tube is better as compare to inner side tube. After establishing influence of these parameters, correlation for prediction of Nusselt number was developed.

Paisarn ,Naphonet al. [10] has studied the thermal performance and pressure drop of the helical-coil heat exchanger with and without helical crimped fins. The heat exchanger consists of a shell and helically coiled tube unit with two different coil diameters. Each coil is fabricated by bending a 9.50 mm diameter straight copper tube into a helical-coil tube of thirteen turns. Cold and hot water are used as working fluids in shell side and tube side, respectively.

Timothy et al. [11] was performed experimental and CFD study on double pipe heat exchanger of two sizes. In the analysis copper tubes of OD of outer tube 15.9 mm and OD of inner tubes of 9.6 and 6.4mm tested. Instead of constant wall temperature or constant heat flux, fluid-to-fluid heat exchanger condition was used.

Biserni [12] was work on inverted fins of different shape such as squre, triangular, rectangular fins.

where after his investigation found thar triangular fins were more efficient than others.

D. G. Prabhanjan , G. S. V. Ragbavan And T. J. Kennic [13,14] has explored experimental study for comparison of heat transfer rates between a straight tube heat exchanger and a helically coiled heat exchanger. Comparisons of heat transfer coefficient weremade between a helically coiled heat exchanger and a straight tube heat exchanger the rise in temperature of the target was greater for the higher bath temperature for both the helical and the straight heat exchangers. The rise in the temperature of the target fluid was significantly affected by both the coil geometry and the flow rate, however, it was not significantly changed by the water bath temperature. The helical coil had a greater increase of temperature compared to the straight tube and the increase of flow rate resulted in a decrease of the temperature rise. The larger temperature rise in the helical coil compared to the straight tube would be due to the secondary flow developed in the coil.

C. X. Lin And M. A. Ebadian [16,17] have worked on developing turbulent convective heat transfer in helical pipes. Numerical study has been carried out to investigate three-dimensional turbulent developing convective heat transfer in helical pipes with finite pitches. k-Ɛ model were used to simulate turbulent flow. Experiment done with Reynolds number range of 2.5 x l04 to 1.0 x l05 , a pitch range of 0.0- 0.6 and a curvature ratio range of 0.025 - 0.050. It has been found that The Nusselt numbers for the helical pipes are oscillatory before the flow is fully developed, especially for the case of relatively large curvature ratio.

Ali et. al. [15,18] correlated the Nusselt number as a function of the Rayleigh number for each of the different heat fluxes used. It was found that the Nusselt number decreased with increasing Rayleigh numbers.

3. CONCLUSION

The performance of heat exchangers can be significantly enhanced by varying geometric design parameters and operational parameters. The research findings from different authors have shown that use of helical baffles can enhance heat transfer coefficient by more than 10%. The baffle cuts have not much impact on heat exchanger performance however number of baffles have significant effect on heat exchanger performance. The helical coil insert geometric design parameters also have significant effect on performance of heat exchanger.

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