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A REVIEW ON HELICAL COIL HEAT TUBE EXCHANGER WITH DIFFERENT CURVATURE RATIO

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ABSTRACT

Helical coil tube heat exchanger is similar with convectional shell and tube heat exchanger except that helical shape tube is used instead of straight tube. In the present work attempt were made to observe the heat transfer characteristics of helical coil tube heat exchanger with different curvature ratio. The experiment was carried out for helical and straight tube heat exchanger with hot water fluid flow inside the tube. Overall heat transfer coefficient was calculated. A computational fluid dynamics package [Ansys Fluent Release 14.5] was used to predict the flow and thermal phenomenon developed in helical coil tube. Validation of the simulations was conducted by comparing heat transfer rate and heat transfer coefficient. It is observed that experimental data is in good agreement with CFD data.

Keywords: *Heat Transfer Characteristics, Helical coil heat exchanger, Curvature Ratio, CFD*

I. INTRODUCTION

A heat exchanger is a device used to transfer heat between one fluid medium to another fluid medium. The fluids are separated by a solid wall to prevent mixing or they may be in direct contact. Heat exchanger have widely used in application such as chemical plants, space heating, refrigeration, air conditioning, power stations, petrochemical plants, petroleum refineries and natural-gas processing. The actual 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, due to increased demands by industry for heat exchange equipment that is less expensive to build and operate than standard heat exchange devices. Many researchers are continuously using new technique to enhance overall performance and reduce the size and costs of heat exchangers. An extensive literature survey of research on all types of enhancement technique is given in Webb and Bergles. Generally, enhancement techniques can be classified in three broad categories [1]:

(a) Active method: Which has been studied widely, involved some external power input to bring about the desired flow modification for enhancement? The active technique required external force such as fluid vibration, electric field and surface vibration.

(b) Passive method: Passive methods do not require external force but made change in geometry or fluid additive which cause heat transfer enhancement. The more commercially interest to enhancement techniques are passive ones. Tube insert devices including twisted tape, wire coil, extended surface and wire mesh inserts are considered as the most important techniques of this group; in which, twisted tape and wire coil inserts are widely applied than others.

It is observed by many authors that the heat transfer in helical coil tube is higher as compared to straight tube due geometrical shape. Helical coil are superior to straight tube due to compactness and high heat transfer coefficient [2]. The flows through a curved pipe have more attention because helical coiled pipes are widely used in practice as heat exchangers in industry. The fluid flowing through curved tubes experiences centrifugal force which induces secondary flow in the tubes. This secondary flow in the tube has significant ability to mixing the fluid and enhances the heat transfer [3].

II. LITERATURE REVIEW

The literature review shows the experimental, analytical and statistical study and analysis of helical tube heat exchanger. In these different parameters such as Curvature ratio, Dean Number, Compactness, Nusselt number, heat transfer coefficient, pressure drop has been studied. Most of the studies have objective to increase the performance of heat exchanger with space reduction. The literature review has classified according to the curvature effect, mass flow rate, and other heat transfer parameters. The methods studied in this survey are experimental method and CFD methodology. These works are reviewed keeping in view the methodology, principles. Some of related works are discussed below.

The first attempt has been made by **Dean 1927 [4]** to describe mathematically the flow in coiled tube. A first approximation of the study of incompressible fluid flowing through a coiled pipe with circular cross section is considered in his analysis. It was observed that the reduction in the rate of flow due to curvature depends on single variable, K, which is equal to 2(Re)2r/R, for velocities and small r/R ratio. The result show that the turbulence does not depends on Reynolds Number and Dean Number. It was conclude that flow through curve pipe in more stable than straight tube.

Kshirsagar et al. 2002 [5] Author found that overall heat transfer coefficient increase with increase in the inner-coiled tube mass flow rate, for a constant flow rate in the annulus region. It also works on maintain constant flow in inner-coiled tube and varies different flow rates in the annulus region. The efficiency of tube-in-tube helical coiled heat exchanger is 15-20% more as compared to conventional heat exchanger and the experimentally calculate efficiency is 93.33%

Harith Noori Mohammed 2009 [6] they work on steady-state natural convection heat transfer from helical coil tubes. Water was used inside and air was used as a coolant fluid. A straight copper tube of 13 mm ID, 14 mm OD and 3 m length was bending to fabricate the helical coil. Two coils are used of curvature ratio of 0.1101 and 0.0942. The results show that the overall heat transfer coefficient and pressure drop are increased when the flow rate of coolant and curvature ratio increase. The curvature ratio 0.1101 gives higher values of overall heat transfer coefficient than the ratio 0.0942, in addition when the curvature ratio of coil increase the Nusselt number values increase also. Two correlations are presented to calculate the average Nusselt number inside and outside of coil.

M. Kahani et. al. 2013 [7] Author work on influence of curvature ratio and coil pitch for Al2O3/water nano fluid laminar flow on heat transfer behavior and pressure drop through helical coils was investigated experimentally. These experiments were performed for coils with curvature ratio 10 and 20 plus coil pitch 24 and 42. The volume fractions of nano particles were 0.25–1.0%. Nano fluids at all concentrations indicated that higher heat transfer rate and pressure drop in comparison with distilled water, which is due to the nano particles present in the fluid. In addition, due to curvature of coils, significant enhancement was observed in heat transfer rate as well as pressure drop when helical coils geometry instead of straight one. Moreover, the heat transfer rate improved with the increase of pitch coils and decrease of curvature ratio. Also, the Nusselt numbers for nano fluid flow inside coils was correlated with helical number, Prandtl number, and volume concentration. It observed that by used of nano fluids in coils, the heat transfer rate can increase up to 320% in compare to distilled water flow in straight tube.

Paisarn Naphon et al. 2006 [8] presented in their paper, effect of curvature ratios on the heat transfer and flow developments in the horizontal spirally coiled tubes are investigated. The spirally coiled tube is fabricated by bending a straight copper tube of 8.00 mm into a spiral-coil of five turns. The spirally coiled tube with three different curvature ratios of 0.02, 0.04, and 0.05 under constant wall temperature condition used. Cold water entering the inner side turn flows along the spiral tube and flows out at the outer side turn. A finite volume method with an unstructured non uniform grid system is employed for solving the model. The simulated results are agreement with the present experiment. The centrifugal force due to bending has significant effect on the enhancements of heat transfer rate and pressure drop. In addition, due to this force, the heat transfer and pressure drop obtained from the spirally coiled tube are higher than those from the straight tube. They has concluded that due to the centrifugal force, the Nusselt number and pressure drop obtained from the spirally coiled tube are 1.49, 1.50 times higher than those from the straight tube, respectively.

Mudhuganti Mahender Reddy et al. 2017 [9] presented the different sodium carboxymethyl cellulose concentrations of Newtonian and non Newtonian fluids under large dean numbers at different flow rates through a helical coil in a mixing coil using paddle impeller. In his work, the results of measured overall heat transfer coefficient for each sodium carboxymethyl cellulose concentration at length of coil L=2.82m and with heat input 1.5kW used in our experimental configuration. It observed that percentage of drag reduction was found up to 98.25% for higher Reynolds number. It also concludes that Entropy generation was more 18% for Newtonian fluids compare to non Newtonian fluids.

S.K.Routa et. al. 2012 [10] presented study has been done using a computational fluid dynamics (CFD) program named ANSYS FLUENT to estimate the performance of the heat exchanger with different fin shapes, sizes and numbers. The results obtained from the study for a steady and laminar flow of fluid under mixed flow convection heat transfer condition shows that there exists an optimum number for fins to keep the pipe wall temperature at a minimum. The wall temperature optimizes at a definite fin height beyond which it is insensitive to any height variation. Moreover, amongst the three different shapes considered for fin, results show that wall temperature is least for triangular shaped fins, compared to rectangular and T-shaped fins. In addition to study of thermal characteristics, the pressure drop caused by presence of fins has also been studied.

V. CONCLUSION

From the above literature survey it is clear that

a) Helical coil tube heat exchanger has higher heat transfer rate than straight tube heat exchanger due to lager surface area.
b) Heat transfer coefficients of the helical coils tube with higher pitch coil are high than those for smaller pitch coil.
c) Experimental study shows that increase in curvature ratio higher the heat transfer rate.
d) Overall heat transfer coefficient increases with increase in hot water mass flow rate at constant mass flow rate of cold water.
e) Effectiveness of heat exchanger increase as increase in curvature ratio.

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