ISSN : 2455-9679
Impact Factor : 2.015

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"A REVIEW ON HELICAL COIL TYPE HEAT EXCHANGERS"

***Ajit Kumar*[1], *Yogesh Kumar Tembhurne*[2], *Dr. Mohit Gangwar*[3]**

[1]*Research Scholar, Mechanical Engineering Department, BERI Bhopal, (M.P.), India*

[2] *Associate Professor, Mechanical Engg. Department, BERI Bhopal, (M.P.), India*

[3]*Professor (Principal), BERI Bhopal, (M.P.), India*

ajibp111@gmail.com
tembhurne06@gmail.com
mohit.gangwar@gmail.com

ABSTRACT

This study presents a brief review of heat transfer through helical coil heat exchangers and purpose of this study is to determine the relative advantage of using a helically coiled heat exchanger against a straight tube heat exchanger. Helical coils of circular cross section have been used in wide variety of applications due to simplicity in manufacturing. The helical coil heat exchangers can be made in the form of a shell and tube heat exchangers and can be used for industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry etc. Enhancement in heat transfer due to helical coils has been reported by many researchers. While the heat transfer characteristics of double pipe helical heat exchangers are available in the literature, there exists no published experimental or theoretical analysis of a helically coiled heat exchanger considering fluid -to-fluid heat transfer, which is the subject of this work. After validating the methodology of CFD analysis of a heat exchanger, the effect of considering the actual fluid properties instead of a constant value is established.

KEYWORDS: *Helical coil Heat exchanger, CFD or computational fluid dynamics, Conjugate heat transfer, Heat transfer correlation.*

I. INTRODUCTION

Helical coil heat exchangers are of great use in industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry, etc due to its compact structure and high heat transfer coefficient. Helical coils of circular cross section have been used in wide variety of applications due to simplicity in manufacturing. Flow in curved tube is different from the flow in straight tube because of the presence of the centrifugal forces. These centrifugal forces generate a secondary flow, normal to the primary direction of flow with circulatory effects that increases both the friction factor and rate of heat transfer. The intensity of secondary flow developed in the tube is the function of tube diameter (d) and coil diameter (D). Due to enhanced heat transfer in helical coiled configuration the study of flow and heat transfer characteristics in the curved tube is of prime importance. Developing fluid-to-fluid helical heat exchangers (fluid is present on both sides of the tube wall) requires a firm understanding of the heat transfer mechanism on both sides of the tube wall. Though much investigation has been performed on heat transfer coefficients inside coiled tubes, little work has been reported on the outside heat transfer coefficients.

Fig.1

II. LITERATURE REVIEW OF PREVIOUS WORK

J.S. Jayakumaret. al [1] presented the effects of the fixed thermal and transfer properties of the system on estimation of the heat transfer coefficients. The CFD based experimentation analysis show that estimated co-efficient is within the permissible range of real-time scenario and the correlation between the two was also presented.

Usman Ur Rehman [2] studied the heat transfer and flow distribution in a shell and tube heat exchanger and compared them with the experimental results. The model showed an average error of around 20% in the heat transfer and the pressure difference.

Nawras H. et.al [3] illustrated the performance of elliptical tubes based on the mechanical and thermal parameters employed for polymer heat exchangers. The mechanical analysis proves that the streamlined shape of the outer tube had an optimal thermal performance based on analysis over different geometries of the tube and materials

K. Abdul Hamid et. al. [4] has done work on pressure drop for Ethylene Glycol (EG) based nanofluid. The nanofluid is prepared by dilution technique of TiO_2 in based fluid of mixture water and EG in volume ratio of 60:40, at three volume concentrations of 0.5 %, 1.0 % and 1.5 %. The experiment was conducted under a flow loop with a horizontal tube test section at various values of flow rate for the range of Reynolds number less than 30,000.

The experimental result of TiO_2 nanofluid pressure drop is compared with the Blasius equation for based fluid. It was observed that pressure drop increase with increasing of nanofluid volume concentration and decrease with increasing of nanofluid temperature insignificantly. He found that TiO_2 is not significantly increased compare to EG fluid. The working temperature of nanofluid will reduce the pressure drop due to the decreasing in nanofluid viscosity.

Shiva Kumar et. al [5] have worked on both straight tube and helical tube heat exchanger. He has compared CFD results with the results obtained by the simulation of straight tubular heat exchanger of the same length under identical operating conditions. Results indicated that helical heat exchangers showed 11% increase in the heat transfer rate over the straight tube. Simulation results also showed 10% increase in nusselt number for the helical coils whereas pressure drop in case of helical coils is higher when compared to the straight tube.

Hemasunder Banka et. al. [6] has done an analytical investigation on the shell and tube heat exchanger using forced convective heat transfer to determine flow characteristics of nano fluids by varying volume fractions and mixed with water ,

 ISSN : 2455-9679
Impact Factor : 2.015

the nano fluids are titanium carbide (TiC), titanium nitride (TiN) and ZnO nanofluid and different volume concentrations (0.02, 0.04, 0.07 & 0.15%) flowing under turbulent flow conditions. CFD analysis is done on heat exchanger by applying the properties of nano fluid with different volume fractions to obtain temperature distribution, heat transfer coefficient and heat transfer rate. He found that heat transfer coefficient and heat transfer rates are increasing by increasing the volume fractions.

III. CHARACTERISTICS OF HELICAL COIL

Fig. 2 gives the schematic of a helical coil. The pipe has an inner diameter *2r*. The coil has a diameter of 2*R*c (measured between the centers of the pipes), while the distance between two adjacent turns, called pitch is *H*. The coil diameter is also called pitch circle diameter (PCD). The ratio of pipe diameter to coil diameter (*r*/*R*c) is called curvature ratio, δ. The ratio of pitch to developed length of one turn (*H*/2π*R*c) is termed non-dimensional pitch, λ. Consider the projection of the coil on a plane passing through the axis of the coil. The angle, which projection of one turn of the coil makes with a plane perpendicular to the axis, is called the helix angle, α. Similar to Reynolds number for flow in pipes, Dean number is used to characterize the flow in a helical pipe. The Dean number, *De* is defined as,

$$De = Re\sqrt{\frac{r}{R_c}}.$$

Where, *Re* is the Reynolds number = $2ru_{av}\,\rho\,/\,\mu$

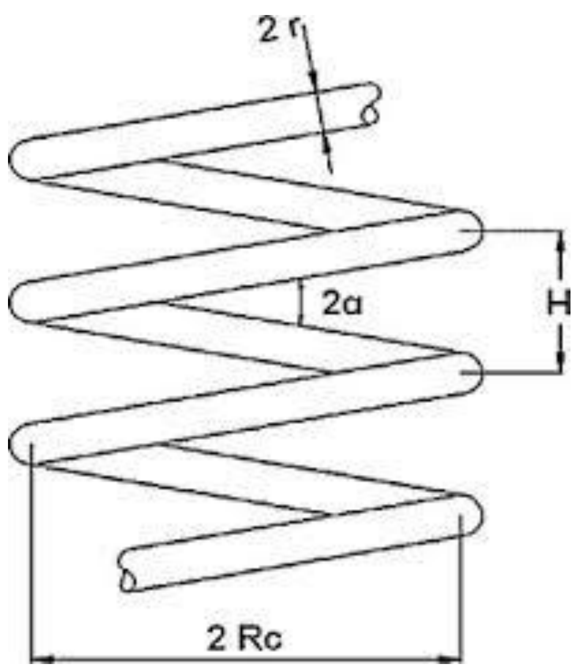

Fig.2 Basic geometry of a helical pipe

Many researchers have identified that a complex flow pattern exists inside a helical pipe due to which the enhancement in heat transfer is obtained. The curvature of the coil governs the centrifugal force while the pitch (or helix angle) influences the torsion to which the fluid is subjected to the centrifugal force results in the development of secondary flow. Due to the curvature effect, the fluid streams in the outer side of the pipe moves faster than the fluid streams in the inner side of the pipe. The difference in velocity sets-in secondary flows, whose pattern changes with the Dean number of the flow. The critical Reynolds number for the transition from laminar to turbulent flow in helical coils is a function of the coil parameters.

IV. CONCLUSION

Comparative study is carried out between helical coil heat exchanger and straight tube heat exchanger, The effectiveness of heat exchanger greatly affected by hot water mass flow rate and cold water flow rate. When cold water mass flow rate is constant and hot water mass flow rate increased the effectiveness decreases. Increase in cold water mass flow rate for constant hot water mass flow rate resulted in increase in effectiveness. For both helical coil and straight tube heat exchangers with parallel and counter flow configuration this result obtained. Helical coil counter flow is most effective in all these conditions and straight tube parallel flow heat exchanger is least effective.

V. FUTURE SCOPE

In all the past research work that has been carried on heat exchanger for effective heat exchanger using only helical coil, made from copper ,aluminium . But no one shows that in the turbulence kinetic energy which materials coils get minimum.

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ISSN : 2455-9679
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