"A REVIEW ON INVESTIGATION OF HELICAL COIL HEAT EXCHANGER "

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ABSTRCT

Heat exchanger are important engineering system with wide variety of application including power plants, refrigeration and air conditioning system, heat recovery system, nuclear reactors, chemical processing and food industries. Working towards the goal of saving energies and to make concise design for mechanical and chemical devices and plants, heat transfer play major role in design of heat exchangers. We are not use application of external power, but we can improve the heat transfer rate by modifying the design by providing the helical tubes, extended surface or swirl flow devices. We improve the heat transfer rate from helical coil tube-in-tube heat exchangers to use Computational Fluid Dynamics (CFD). My project aims to perform a numerical study of helical coil tube-in-tube heat exchanger with water as both hot and cold fluid. To improve the effectiveness, heat transfer rate and reduce power consumption, D/d geometrical parameter will be varied for different boundary conditions. The impact of this modification on Nusselt number, friction factor, pumping power required and LMTD variation of inner fluid with respect to Reynolds number was studied.

Keyword *Helical coil heat exchanger, Heat transfer, Nusselt number, LMTD, Reynolds number*

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1. INTRODUCTION

The heat exchanger is a device which is used to transfer heat between two fluids which may be in direct contact or may flow separately in two tubes or channels. We find many applications of heat exchangers in day to day life. A heat exchanger may be defined as equipment which transfers the energy from a hot fluid in a cold fluid, with maximum rate and minimum investment and running cost. The rate of transfer of heat depends on the conductivity of the dividing wall and convective heat transfer coefficient between the wall and fluids. The heat transfer occurs by three principles: conduction, convection and radiation. In a heat exchanger the heat transfer through radiation is not taken into account as it is negligible in comparison to conduction and convection.A counter flow tube in tube helical coil heat exchanger where hot water flows through the inner tube and cold water flows through the outer tube. A wire is wound over the inner tube to increase the turbulence in turn increases the heat transfer rate. [1]

Bell-Delaware method is based on the heat transfer coefficient and pressure drop are estimated from correlations for flow over ideal pipes, and the effects of leakage, bypassing and flow of fluid in the pipe zone are allowed for by applying correction factors.

In Kern's method-is based on experimental work on commercial exchangers with standard tolerances and give a normally condign divination of the heat-transfer coefficient for authentic designs. Basic relation of over all heat transfer coefficient is $Q = U_0 A_S \Delta T_{LMTD}$

Helical Coil Heat Exchanger

Today, Evolution of design of heat exchangers to full fill over requirement to development helical coil heat exchanger as helical coil has many benefit over a straight tube.

Fig 1 Double pipe helical coil

Fig 2 Close-up of double pipe coil

Advantages

- Heat transfer rate in helical coil are higher as compared to a straight tube heat exchanger. Compact structure.
- It required small amount of floor area compared to other heat exchangers.
- Larger heat transfer surface area.

Applications

- Heat exchangers with helical coils are widely used in industries. The most common industries where heat exchangers are used a lot are power generation plants, nuclear plants, process plants, refrigeration, heat recovery systems, food processing industries, etc.
- Helical coil heat exchanger is used for residual heat removal system in islanded or barge mounted nuclear reactor system, where nuclear energy is used for desalination of sea water.
- In cryogenic applications including LNG plant.

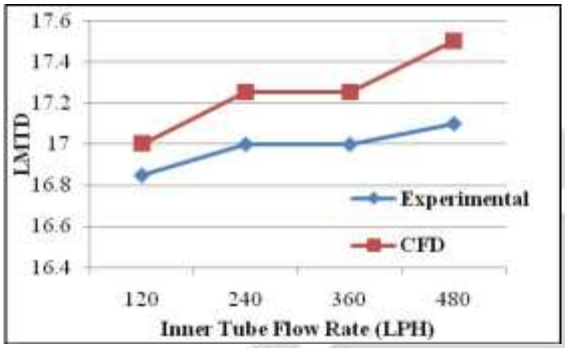
2. LITERATURE REVIEW

Jayakumar [2] had study on numerical and experimental work on helical coil heat exchanger considering fluid to fluid heat transfer. They had taken different boundary conditions for constant heat flux, constant wall temperature and constant heat transfer coefficient. In their observation they had found that constant value of thermal and transport properties of heat transfer medium results inaccurate heat transfer coefficient. In practical applications, the heat transfer in fluid to fluid heat exchangers in boundary conditions such as constant wall temperature or constant heat flux conditions are not applicable. Based on the numerical and experimental analysis within certain error limits correlation was developed to calculate the inner heat transfer coefficient of helical coil.

Rahul Kharat, Nitin Bhardwaj, R.S. Jha [3]have observed on development of heat transfer coefficient correlation for concentric helical coil heat exchanger. He suggested to One extra parameter has been introduced to capture the strong correlations between coil gap and heat transfer coefficient. A wide range of data has been analyzed, which covers a wide range of the Reynolds number from 20 000 to 150 000. It is found that the extreme range of data identified by the ratio of coil gap and tube diameter can introduce significant error in the equation. These extreme data is filtered to develop a better equation. As these data is filtered, the equation is not valid in this extreme range. The developed equation is only valid, if the specified ratio (Coil gap/ Tube diameter) is from 0.55 to 2.25.To analyze the effect of tube diameter on the heat transfer coefficients, the heat transfer coefficients are evaluated for the different tube diameter keeping inner coil pitch circle diameter, outer coil pitch circle diameter and velocity constant. Inner and outer coil diameters are kept constant to neutralize the effect of hydraulic diameter on the heat transfer coefficient.

Ganesh Mhaske and Prof D. D. Palande [4] study on Experimental and CFD Analysis of Tube in Tube Helical Coil Heat Exchanger. They compare Experimental and CFD results. By comparing Experimental and CFD results of wire wounded Tube in Tube Helical Coil Heat Exchanger, they had observed that inner tube flow rate

(LPH) increases so inner heat transfer coefficient was improve. They study and proved that Nusselt Number is directly proportional to inner heat transfer coefficient. For constant Cold Water Flow Rate, They study improve Nusselt Number so increasing inner tube flow rate, They also found that inner tube flow rate (LPH) directly proportional to temperature difference. For constant Cold Water Flow Rate, Log mean temperature difference (LMTD) is directly proportional to inner tube flow rate. They found that inner tube flow rate (LPH) increases with increase heat gain by cold water.



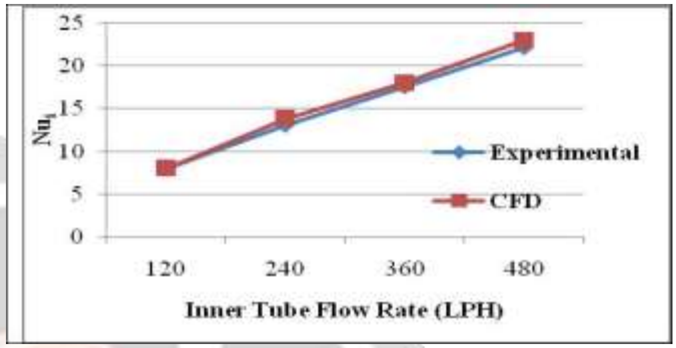


Chart 1 LMTD Vs Inner Tube Flow Rate (LPH)

Chart 2 Nusselt Number(Nu_i) Vs Inner Tube Flow Rate

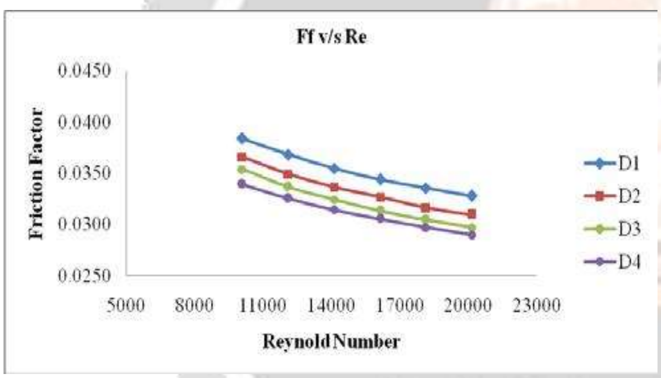
Mrunal p.kshirsagar, trupti j. kansara, swapnil m. aher[5]has observed on fabrication and analysis of tube-in-tube helical coil heat exchanger. Experimental study of a wire wound tube-in-tube helical coiled heat exchanger was performed considering hot water in the inner tube at various flow rate conditions and with cooling water in the outer tube. The mass flow rates in the inner tube and in the annulus were both varied and the counter-current flow configurations were tested. The experimentally obtained overall heat transfer coefficient (U_o) for different values of flow rate in the inner-coiled tube and in the annulus region were reported. It was observed that the overall heat transfer coefficient increases with increase in the inner-coiled tube flow rate, for a constant flow rate in the annulus region. Similar trends in the variation of overall heat transfer coefficient were observed for different flow rates in the annulus region for a constant flow rate in the inner-coiled tube. It was also observed that when wire coils are compared with a smooth tube, it was also observed that overall heat transfer coefficient is increases with minimum pitch distance of wire coils. The efficiency of the tube-in-tube helical coil heat exchanger is 15-20% more as compared to the convention heat exchanger and the experimentally calculated efficiency is 93.33%.

Chinna Ankanna[6] :The present days Heat exchangers are the important engineering systems with wide variety of applications including power plants, nuclear reactors, refrigeration and air-conditioning systems, heat recovery systems, chemical processing and food industries. Helical coil configuration is very effective for heat exchangers and chemical reactors because they can accommodate a large heat transfer area in a small space, with high heat transfer coefficients. Increase in the effectiveness of a heat exchanger and analysis of various parameters that affect the effectiveness of a heat exchanger and also deals with the performance analysis of heat exchanger by varying various parameters like number of coils, flow rate and temperature. The results of the helical tube heat exchanger are compared with the straight tube heat exchanger in both parallel and counter flow by varying parameters like temperature, flow rate of cold water and number of turns of helical coil.

Timothy J. Rennie [7]studied the heat transfer characteristics of a double pipe helical heat exchanger for both counter and parallel flow. Both the boundary conditions of constant heat flux and constant wall temperature were taken. The study showed that the results from the simulations were within the range of the pre-obtained results. For dean numbers ranging from 38 to 350 the overall heat transfer coefficients were determined. The results showed that the overall heat transfer coefficients varied directly with the inner dean number but the fluid flow conditions in the outer pipe had a major contribution on the overall heat transfer coefficient. The study showed that during the design of a double pipe helical heat exchanger the design of the outré pipe should get the highest priority in order to get a higher overall heat transfer coefficient.

Sadashiv and Madhukeshwara.N [8]have worked on Numerical simulation of enhancement of heat transfer in a tube with and without rod helical tape swirl generators .The study show A CFD analysis has been conducted to investigate heat transfer enhancement by means of helical tape inserts in a double pipe heat exchanger using cold water and hot air as the test fluids. The flow rate of the tube is considered in a range of Reynolds number between 2300 and8800. The swirling flow devices consisting of: the full length helical tape with or without center rod of a concentric tube heat exchanger. The data obtained by simulation are matching with the literature value for a plain tube with the discrepancy of less than plus or minus 5% for Nussult number and for the friction factor. Enhanced heat transfer with decreasing twist ratio has been observed. Heat flux is more uniform all along the tube and decreases uniformly towards the center. From the experimental results, it can be found that enhancing heat transfer with passive method using different types of helical tape construction in the inner tube of a concentric double pipe heat exchanger can improve the heat transfer rate efficiently.

Mohammed Imran , Gaurav Tiwari and Alwar singh Yadav [9]have studies on cfd analysis of heat transfer rate in tube in tube helical Coil heat exchanger. They carried out on helical coil tube-in-tube heat exchanger is done for different boundary conditions and optimizes condition of heat transfer is found out for different D/d ratio. The turbulent flow model with counter flow heat exchanger was considered for analysis purpose. The effect of D/d ratio on heat transfer rate and pumping power was found out for different boundary conditions. Numerical simulation has been carried out for tube in tube helical coil heat exchanger subjected to different boundary conditions. They were study and show results that increase in the Reynolds number, the Nusselt number for the inner tube increase. They show that increase in D/d ratio (inverse of curvature ratio)will decreases the Nusselt number.; for a particular value of Reynolds number. Nusselt number has maximum value for D/d=25. When Reynolds number increases Friction factor decreases due to relative roughness of surface, and velocity of flowing fluid. When Reynolds number increases, Log mean temperature difference increases at a steady rate.



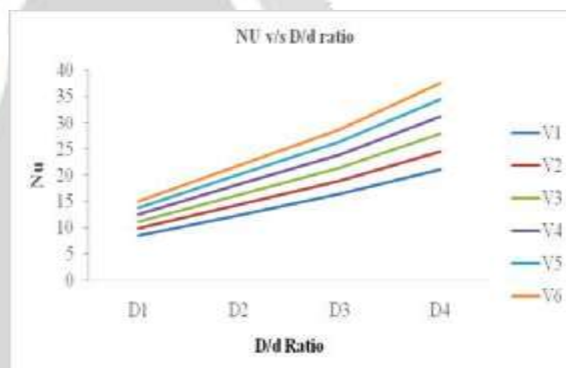


Chart 3friction factor Vs Re for different D/d ratio **Chart 4** Nu Vs D/d Ratio

P. P. Gavade, S.S. Malgave, D.D. Patil, H.S. Bhore, V. V. Wadkar[10] has studies on tube in tube helical coil & straight tube heat exchanger that the fluid which surrounds a heat source receives heat, becomes less dense and rises. The working fluid that is surrounding the high temperature fluid is cooled and then moves in to replace it. After that cooler fluid gets heated and the process continues, resulting convection current. Forced convection in a heat exchanger is the flow of heat from one moving stream to another stream through the wall of the pipe. The low temperature fluid removes heat from the comparatively high temperature fluid as it flows along or across it.[10]

3. CONCLUSION

Literature review show that develop in coil configuration, so improvement in heat transfer coefficient done by some changes in coil configuration. It is observed that CFD data is good agreement with experiment results.CFD model take into account for retrieve geometry and obtain optimum design. Numerical simulation has been carried out for tube in tube helical coil heat exchanger subjected to different boundary conditions. Nusselt number, Darcy friction factor, pumping power required, Log mean temperature difference, pressure drop variation with respect to Reynolds number for different D/d ratio is plotted. Heat transfer behaviors for different boundary conditions are predicted and optimize condition for maximum Nusselt number (Nu) and minimum friction factor (f) was plotted against Reynolds number.

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