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A Review of Helical Coil Heat Exchangers for Different Parameters

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Abstract - For industrial applications such as chemical, food processing, power production, space heating, refrigeration and air conditioning industries, heat exchangers are widely used for exchange of heat. In order to obtain a large heat transfer per unit volume and to enhance the heat transfer rate in the interior surface, helical coil heat exchangers are widely used. Parameters like diameter of tube, coil pitch, mass flow rate, pitch circle diameter or curvature diameter of coil directly affect the heat exchanger's performance. In present study, a helical coil heat exchanger is modelled. The effect of variation in mass flow rate and coil diameter on its performance has been studied using commercial CFD software. The mass flow rate has been varied for all the coil diameters. Variation in pressure drop, water velocity, temperature, Reynold's number and Nusselt number have been found out for all the cases and a comparison has been made.

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I. INTRODUCTION

Heat transfer is the exchange of heat between physical systems. The rate of heat transfer depends on the temperatures of the systems and the properties of the intervening medium through which the heat is transferred. The different modes of heat transfer are viz. conduction, convection and radiation. Heat exchanger is a device which is used to transfer heat from one fluid to another fluid by means of conduction or convection. In other words it can also be defined an equipment which transfers energy from hot fluid to cold fluid with maximum desired rate. Heat exchanger contains two fluids one is hot fluid while the other is cold fluid. Heat exchanger plays an important role in the field of industries or in many operation systems.

Both the fluids in heat exchanger passes through the separating walls, the temperature of hot and cold fluid vary along the length of heat exchanger as they flow. Heat exchangers is utilized in many industries such as power production industries, food and chemical industries, refrigeration and air conditioning system, petroleum refining industries, petrochemical plant, natural gas plant and in automotive operations. Heat transfer in heat exchangers takes place due to the temperature difference in the two fluids without use of any external energy. One of the important examples of heat exchanger is radiator of car which transfers heat from water to air. In now a day's many different types of heat exchangers are constructed which provides high rate of heat transfer.

II. DESIGN AND CONSTRUCTION OF HEAT EXCHANGERS

In order to achieve high rate of heat transfer heat exchangers have different designs as well as it should provide high surface area with minimum space. Following heat exchangers are classified on the basis of design and constructions are as follows.

A. Concentric or Tube in Tube Heat Exchanger

In a concentric tube heat exchanger two tubes are used. Inside tube is called inner tube whereas outside tube is called outer tube. Basically, in concentric tube heat exchanger small tube concentrically fixed in large tube. Hot fluid passes through the inner tube whereas cold fluid flows in the outer tube or flows over the surface of inner tube. Concentric tube heat exchangers are used when the flow rate is low. It is easy to construct but it require large space to increase surface area in order to obtain desired heat transfer

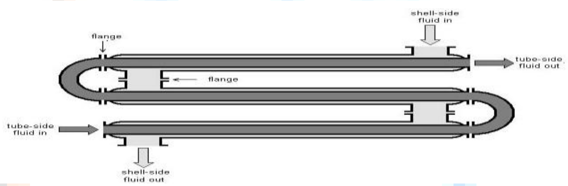

Fig 1: Concentric or tube in tube heat exchanger

B. Shell and Tube Heat Exchanger

Shell and tube heat exchanger is one of the most common heat exchange device which is mostly found in plants. Shell and tube heat exchanger contains number of tubes which are enclosed together inside the shell through tube sheet. One fluid passes through the tubes and the other fluid flows over the surface of tube inside the shell. Heat transfer rate of shell and tube heat exchanger depends upon the number of tubes. Baffle plates are attached in inside the shell which gives the direction of flow to shell fluid. Shell and tube heat exchanger provide large surface area in a small space. It can operate under high pressure and easy to clean

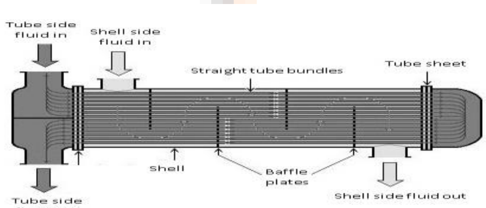

Fig 2: Shell and tube heat exchanger

C. Multi Shell and Tube Heat Exchanger

Multi shell and tube heat exchanger increases the overall heat transfer of coefficient. Multi shell and tube heat exchangers effected only when fluid inside the shell re-routed. Due to the presence of baffle plates, fluid inside the shell moves back and forth

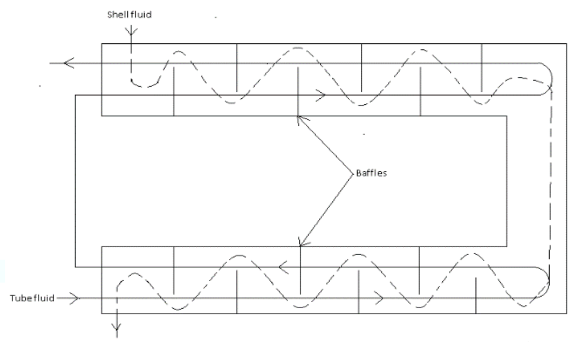

Fig 3: Two shell and four tube pass heat exchangers

III. LITERATURE REVIEW

Sheeba et al., -did experimental and numerical investigations on a helically coiled double pipe heat exchanger. Its heat transfer and flow characteristics were studied. Parameters affecting heat transfers were studied. Overall heat transfer coefficients were calculated and Wilson plot was used to find the heat transfer coefficients. Validation of numerical work with experimental has also been carried out. It was found that use of helical coil heat leaded to an enhancement in the Nusselt number. But the friction factor is high for helical coil. The overall heat transfer coefficient varied with pitch and there existed an optimum value of pitch. A correlation has also been proposed to estimate Nusselt number in terms of Dean number, Prandtl number and dimensionless pitch.
Hameed and Hamid- utilized various techniques to improve the performance of heat exchangers. Triangular fins were fabricated on the outside surface of the longitudinal helical heat exchanger. The performance of the new heat exchanger was investigated experimentally and mathematically. For the considered design, good enhancement ratio was obtained. Effectiveness improved by 11%, Nusselt number improved by 16.5%. It was concluded that adding fins improved the performance of the heat

exchanger and makes the exchanger suitable for industrial applications with better performance.

Rafał, and Muszyński - presented the usage of shell and coil type of heat exchanger. The usage includes heating, ventilation, nuclear industry, process plant, heat recovery and air conditioning systems industries. It was clarified that these kinds of recuperators have low value of pressure drop and are simple in construction. The authors also developed their own shell and tube heat exchanger with high heat transfer. The surface of the exchanger was modified to enhance the effectiveness. Steady state conditions were considered for the experimental studies. Experimentation was done for laminar and transient conditions with parallel flow and counter flow conditions. Many number of transfer units analysis was carried out to find optimal heat transfer intensification on the shell-side.

Naik and Vinod- investigated heat transfer using three non-Newtonian nanofluids (Fe_2O_3, Al_2O_3 and CuO nanoparticles in aqueous carboxymethyl cellulose base fluid) for shell and helical coil heat exchanger. Nano fluid wqas prepared using nano particles in the concentration range of 0.2- 1.0% by weight. Nanofluid and water were used on shell side and tube side respectively. Overall heat transfer was found out. Parameters such as Nusselt number, at different conditions such as flow rate of cold water (0.5–5 lpm), shell side fluid (nanofluid) temperature (40–60 °C) and stirrer speeds (500–1500 rpm) were varied. It was found out that Nusselt number increase with increasing nanofluid concentration. It was also found that the CuO/CMC-based nanofluid showed better heat transfer than Fe_2O_3 and Al_2O_3 fluids.

Zhend et al.,- experimentally and numerically studied performance of a high-density polyethylene helical coil heat exchanger which was adopted by a seawater-source heat pump system. Numerical studies for Correlation between Nusselt and Reynolds number were found out to be in agreement with experimental values. Various inlet conditions such as inlet temperature, velocity of intermediate medium, pipe length and diameter, temperature of seawater and icing outside the pipes were varied to study their effect. It was concluded that mathematical models are helpful in designing and optimizing seawater-source heat pump system.

Zarei et al. - investigated cold thermal energy storage (CTES) using a helical coil heat exchanger modified with bubble injection. Experimental studies were carried out to examine the impact of bubble injection on Nusselt number, the temperature differences in the storage tank, exergy degradation in the evaporator, and cycle coefficient of performance. It was found out experimentally that bubble injection significantly improved the COP and heat transfer rate from the storage tank, as well as the exergy destruction and Nusselt number.

Bhanvase, et al., - enhanced heat transfer with the use of water based PANI (polyaniline) nanofluid for vertical helical coiled tube heat exchanger. Nanofibers were prepared using ultrasound assisted emulsion polymerization method. Then they were dispersed in base fluid with varying concentration to get the desired working fluid. It was found out that heat transfer increased by 10.52% at 0.1% concentration.

Omidi et al.,- numerically investigated the flow characteristics and heat transfer applications of a helical coil with four different lobed cross sections. Reynolds number has been varied for constant temperature of helical coils (373 K). It was found that exchanger with 6 coils had highest Nusselt number and lowest friction coefficient. It was concluded that coil diameter was the most important parameter which affected the performance of heat exchanger. Nusselt number also increased by 28% on using Al_2O_3-Water nanofluid.

Nilay et al., - presented CFD simulation for helical coil heat exchanger for varying mass flow rates. Inlet water was kept at constant temperature. For various geometric variations, parameters such as temperature drop, heat transfer rate, heat transfer coefficient and Nusselt number were found out and compared. It was concluded that heat transfer increased with increase in coil diameter and flow rates.

Reddy et al.- discussed the usage of helical coil heat exchangers because of their compactness, larger heat transfer area and high heat transfer capabilities. Helical coil heat exchangers are currently being also used in many industries such as food, power, electronics, environmental, etc. Helical coils are extensively used as heat exchangers due to higher heat and mass transfer coefficients.

IV. CONCLUDING REMARKS FROM LITERATURE REVIEW

Computational Fluid Dynamics is one of the best ways to predict the performance of heat exchangers in design phase. Helical coil heat exchangers are one of the most promising kinds of heat exchangers where heat transfer needs to be done in compact places. There is further scope of research for experimental as well as numerical simulation for helical coil heat exchangers for varying parameters and working fluids.

1. Many researchers have worked on CFD analysis of helical coil heat exchanger. But many few have worked for finding out detailed flow characteristics for variation in flow parameters.
2. Very few researchers have given in detail flow patterns, pressure drop and velocity distribution pictorially.
3. The working performance and efficiency of the heat exchanger is affected by the complex fluid.

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