A Review Paper Based On Performance Analysis of Heat Exchanger Using Helical Fins with Varying Pitch

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Abstract— In thermal industry, heat exchanger is very important device. The heat exchangers are used in number of applications. Heat exchangers are devices that facilitate the exchange of heat between two fluids that are at different temperatures while keeping them away from mixing with each other. As heat exchangers are used in many applications, the efficient heat exchangers have tremendous demand from industry. From last few years, efforts have been done to enhance heat transfer, increase rate of heat transfer, minimize size of heat exchangers, and finally increase energy and fuel efficiencies. The researchers are using different inserts, fins, fin shapes, insulations to ensure efficient and enhanced heat transfer.

Key words: Heat exchanger, Heat transfer, Heat transfer rate, Size of heat exchangers, fins, fin shapes, insulations

I. INTRODUCTION

Extended surfaces are used to enhance convective heat transfer in a wide range of engineering applications and offer a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation transformers. Other applications include Internal Combustion engine cooling such as fins in a car radiator. It is important to predict the temperature distribution within the fin in order to choose the configuration that offers maximum effectiveness.

The researchers have two main approaches, active techniques and passive techniques. In many applications passive techniques like extended surfaces (fins) are preferred as the additional energy is not required. Use of extended surfaces is a main research stream in which many researchers are working and exploring the different aspects of extended surfaces to give heat transfer enhancement. As fins are easy to install, produce and operate they are becoming a famous heat transfer enhancement technique.

The helical fins on tube of heat exchangers will transfer more heat as it will create a swirl motion along the periphery of the pipe as fluid moves towards the exit. As helical fins provide pathways for the swirl motion, the path governs the movement of the fluid; hence, change in path of the fluid by changing the pitch of the helical fins also have impact on the heat transfer. Hence, in this paper, effect of helical fins and varying pitch of the fins on the heat transfer in heat exchanger will be studied.

II. LITERATURE REVIEW

The heat transfer enhancement is an important branch of research in the thermal engineering as it has great scope from the thermal, process and automobile industry. Many researchers are working in the enhancement of heat transfer processes; some of their research is listed below.

Zhengguo Zhang et al. [1] were made attempts to investigate the heat transfer characteristics of a helically baffled heat exchanger combined with one three-dimensional finned tube. For the counter mode operation, experiments were carried out and overall heat transfer coefficient determined using modified Wilson plot. The agreement with the numerical and experimental predictions of Nusselt number and pressure drop values were well within 6.3% for Nusselt number and 9.8% for pressure drop in the shell side respectively.

Choudhari et al. [2] studied heat transfer characteristics and friction factor of horizontal double pipe heat exchanger with coil wire inserts made up of different materials are investigated. The Reynolds numbers are in the range of 4000-13000. The inner and outer diameters of tubes are 17 mm and 21.4 mm respectively. Hot water and cold water are used as working fluid on tube side and annulus side respectively. The hot water and cold water flow rates are maintained same and in range of .033 to .1 kg/s. Three different materials as Copper, Aluminum and Stainless Steel and different pitches are used. Aluminum, Copper and Stainless Steel inserts are of pitches 5, 10 and 15 mm respectively. Effect of these coil wire insert materials on enhancement of heat transfer and friction factor are considered. The experimental data obtained from plain tube were verified with the standard correlation to ensure the validation of experimental results. Coil wire has significant effect on heat transfer and friction factor. Copper insert has higher heat transfer enhancement of 1.58 times as compared to plane tube. On the other hand, Aluminum and Stainless Steel inserts have heat transfer enhancement of 1.41 and 1.31 as compared to plane tube respectively. The friction factor found to be increasing with decreasing coil wire pitch.

Ankanna et al. [3] analyze the fabricated helical coil heat exchanger. This paper focus on an 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.

Shewale et al. [4] conducted an experimental investigation of double-pipe heat exchanger with helical fins on the inner rotating tube. In this work, to improve the heat transfer characteristic of the double pipe heat exchanger with the helical fins were installed on the outer surface of the inner tube and the level of turbulence increased by the rotating the inner tube. The length of heat exchanger was 1

m and the pitch of helical fins kept constant equal to 17 mm. The convective heat transfer coefficients were obtained for the stationary as well as rotating inner tube for the counter flow mode using water as cold fluid in the tube side and Glycerol as hot fluid in the shell side.

Indhe et al. [5] has conducted an experimental and analytical study to optimize longitudinal fin profile for double pipe heat exchanger. In this present study, the performance of the heat transfer process in a given heat exchanger is determined for longitudinal fin profiles (rectangular). The performance of a double pipe heat exchanger is analyzed in two parts that is optimization and experimentation. In the part of optimization, numerical analysis was performed by MATLAB program. This program serves to optimize the fin height so as to obtain maximum possible heat transfer without any wastage of material at a given length and inlet conditions. Also, all the performance parameters such as efficiency, pressure drop, effectiveness, heat transfer coefficient, outlet temperature of both fluids, overall heat transfer coefficient were studied simultaneously for all possible fin height. In second part, experimentation is carried out in a counter flow double pipe heat exchanger for varied mass flow rate which ranges from 0.0168 kg/s to 0.0126 kg/s. Experimental results and analytical result shows that for optimum height, effectiveness is increased up to 23% and heat transfer is enhanced by 26% than unfinned pipe

Gada et al. [6] has conducted experimental analysis of helical coil heat exchanger with & without fins. This work is focused on an increase in the effectiveness of a heat exchanger by brazing the fins on its external surface so as to increase the heat transfer rate by increasing its effective area. The thermal analysis is carried out considering the various parameters such as flow rate of cold water, flow rate of hot water, temperature, effectiveness and overall heat transfer coefficient. From this work, it is observed that, the variation in tube diameter has greater influence on temperature drop and pressure drop. As the tube diameter goes on reducing, the temperature drop increased along with loss of pressure i.e. pressure drop occur due to which pumping power increases.

III. THEORY

A. *Heat Exchanger:*

Heat Exchangers are the class of equipment used to transfer heat in industrial processes. Most often the transfer of heat takes place between two fluid streams. However, in certain cases heat may also transfer to vacuum (as in the case of space radiators). Truly speaking, the term 'Heat Exchanger' is a misnomer. Heat is never 'exchanged' but 'transferred'. The difference between these two terms is that, exchange means to transfer in lieu of something, whereas, transfer indicates unconditional flow in one direction. Hence, the equipment transferring heat should have been called 'Heat Transmitter'. However, engineers have decided to stay with the traditional term 'Heat Exchanger' often abbreviated as 'HX'.

The use of Heat exchangers is extensive in power, chemical processes, nuclear, aerospace, food processing, petrochemical, metallurgical, refrigeration and cryogenic industry. Even though the underlying principles, of the construction of heat exchangers are essentially those of conduction, convection, and sometimes radiation, the application of these principles is not very straightforward. In some applications, some specific factor may gain a controlling importance, for example, weight and space requirements are of prime concern in the aerospace industry which uses compact heat exchangers; regular cleaning is a requirement of the brewing and dairy industry and hence that use plate heat exchangers which can be readily disassembled and assembled and so on.

B. *Helical Fins:*

Fins are quite often found in industry, especially in heat exchanger industry as in finned tubes of double-pipe, shell-and-tube and compact heat exchangers. As an example, fins are used in air cooled finned tube heat exchangers like car radiators and heat rejection devices. Also, they are used in refrigeration systems and in condensing central heating exchangers. Moreover, fins are also utilized in cooling of large heat flux electronic devices as well as in cooling of gas turbine blades. Fins are also used in thermal storage heat exchanger systems including phase change materials. To the best knowledge of the authors, fins as passive elements for enhancing heat transfer rates are classified according to the following criteria.

- Geometrical design of the fin.
- Fins arrangements
- Number of fluidic reservoirs interacting with fin.
- Location of fin base with respect to solid boundary.
- Composition of the fin.

According to design aspects, fins can have simple designs, such as rectangular, triangular, parabolic, annular, and pin rod fins. On the other hand, fin design can be complicated such as spiral fins. In addition, fins can have simple network as in finned tubes heat exchangers. In contrast, they can be arranged in a complex network as can be seen in the works of. Moreover, fins can be further classified based on the fact whether they interact thermally with a single fluid reservoir or with two different fluid reservoirs. Example of works based on the last classification is the works of Khaled. In addition, fins can be attached to the surface as in the works or they may have roots in the heated/cooled walls. Finally, fins can be solid or they can be porous or permeable.

Several studies have indicated that helically coiled fins superior to straight fins when employed in heat transfer application. The various designer and researcher are made study on various shell and coiled tube heat exchanger with varying coil diameter, coil pitch, tube diameter and curvature ratio.

IV. SCOPE OF WORK

Heat transfer augmentation in heat exchangers has huge scope as it will lead to the energy saving on mass scale in automobile industry, Refrigeration and Air conditioning industry, Thermal industry and process industry. This work consists of study of the effect of helical fins on heat transfer and is also consists of study of effect of varying pitch on heat transfer. The findings of this work will lead to enhanced heat transfer in heat exchangers which will provide energy efficient thermal device. Due to enhancement in performance of these systems will cause

energy saving in all these applications where heat exchangers are used. As heat exchangers are used in mass scales it will cause more energy saving.

V. OBJECTIVES OF WORK

The objectives of this work are,

- To design a test rig for investigation of heat transfer in double pipe heat exchanger.
- To investigate performance of system without application of helical fins.
- To investigate performance of system with application of helical fins with their varying pitches.
- To measure a pressure drop occurring in a system.

VI. THEORETICAL WORK

The theoretical work includes,

- To review the recent research work regarding heat transfer enhancement of helical fins.
- Design of test rig for experimental investigation of heat transfer enhancement with helical fins.

VII. EXPERIMENTAL WORK

Experimental work consists of,

- To develop test rig for experimental investigation.
- To investigate performance of plain double pipe heat exchanger.
- To investigate performance of system with application of helical fin with its varying pitches.

VIII. EXPERIMENTAL SETUP

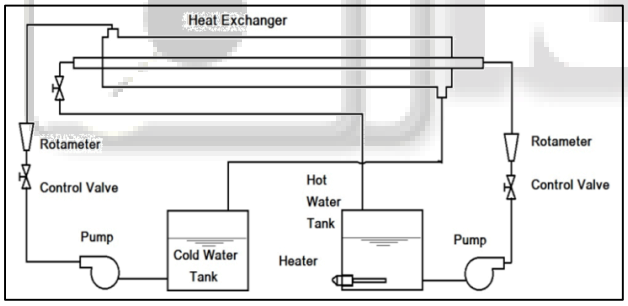

Fig. 1: Layout of experimental setup

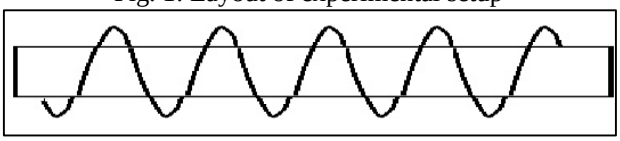

Fig. 2: Arrangement of helical fin over inner tube

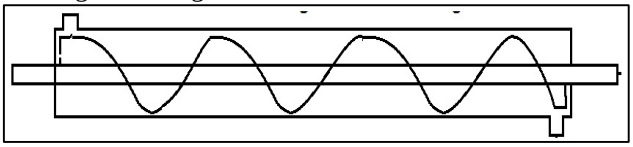

Fig. 3: Arrangement of helical fin and tube inside the shell

IX. EXPECTED OUTCOME

After this research work will lead to findings on the effect of helical fins and their varying pitch on heat transfer enhancement in double pipe heat exchanger. It is expected from this research work that the applications of helical fins will enhance the heat transfer in heat exchanger by providing turbulence and spiral movement of fluid in the outer tube of the heat exchanger. Also the exact effect of varying pitch on the heat transfer also find out from this work.

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