A Review on Double Pipe Heat Exchanger with Straight and Helical Fins

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***Abstract*- The plate fin-and-tube heat exchangers are widely used in variety of industrial applications, particularly in the heating, air-conditioning and refrigeration, HVAC industries. In most cases the working fluid is liquid on the tube side exchanging heat with a gas, usually air. It is seen that the performance of heat exchangers can be greatly increased with the use of unconventionally shaped flow passages such as plain, perforated offset strip, louvered, wavy, vortex generator and pin. The current study is focused on wavy-fin. The wavy surface can lengthen the path of airflow and cause better airflow mixing. In order to design better heat exchangers and come up with efficient designs, a thorough understanding of the flow of air in these channels is required.**

***Index terms*- Heat transfer, Fluid flow, Turbulent Flow, Double Pipe Heat exchanger, Helical Fin**

1. INTRODUCTION

Heat exchangers were used in a wide-ranging of applications including power generation plants, nuclear reactors for generation of electricity, Refrigeration & Air Conditioning (RAC) systems, self-propelled industries, food industries, heat retrieval systems, and chemical handling. The upgrading methods can be distributed into two groups: active and passive methods. The active method requires peripheral forces. The passive methods need discrete surface geometries. Both methods have been commonly used to improve performance of heat exchangers. Due to their compact structure and high heat transfer coefficient helical tubes have been declared as one of the passive heat transfer improvement method and they are broadly used in many industrial applications [1, 4, 16].

The development of high performance thermal systems has stimulated interest in methods to improve heat transfer. In heat exchangers, enhancement of heat transfer is achieved by increasing the convection heat transfer coefficient or by increasing the convection surface area. One of the method to increase the convection coefficient within a heat exchanger is by introduces inserts within the pipes/tubes.

Heat Exchanger is a device in which the exchange of energy takes place between two fluids at different temperature. A heat exchanger utilizes the fact that, where ever there is a temperature difference, flow of energy occurs. So, that Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them. The energy flowing in a heat exchanger may be either sensible energy or latent heat of flowing fluids. The fluid which gives its energy is known as hot fluid. The fluid which receives energy is known as cold fluid. It is but obvious that, Temperature of hot fluidwill decreases while the temperature of cold fluid will increase in heat exchanger. The purpose of heat exchanger is either to heat or cool the desired fluid.

2. LITERATURE SURVEY

Lachi et al. (2018) studied time constant of a DPHE and a shell and tube heat exchanger. The particular purpose of this investigation was to classify the characteristics of these heat exchangers in a transient condition, especially the time when abrupt changes in inlet velocities are considered. Upon carrying out this study, a model with two parameters of time delay and time constant has been employed. It is also noted that the analytical term was derived by applying energy balance equation. Moreover, it was stated that an experimental method was used to validate the numerical data which the highest observed difference found to be less than ten percent.

Aicher and Kim (2018) investigated the effect of counter flow in nozzle section of a DPHE which were mounted on the wall of the shell side. It turned out that the counter flow in nozzle section had a significant effect on heat transfer and pressure drop. It was also concluded that the very effect would be more conspicuous, if the heat exchanger were small and also the ratio of free cross section areas were low enough. They also presented experimental correlations to predict heat transfer rate in turbulent flow.

Ma et al. (2018) experimentally investigated the effects of supercritical carbon dioxide (SCO2) in a DPHE in which the effects of pressure, mass flux and buoyancy force of the SCO2-side were broadly studied. On one hand, it was observed that pressure increase of the gas-side conspicuously caused both the overall and the gas-side heat transfer rates to be decreased. On the other hand, it was obvious that the flow rate of the waterside, in comparison with the gas-side, was the key element of the heat transfer rate. Moreover, a mathematical correlation based on Genetic Algorithm was presented for predicting heat transfer rate.

Raghavan (2018) investigated a double pipe helical heat exchanger for both parallel and counter flow configurations. The corresponding heat transfer rates of inner tube and the annulus were calculated using Wilson plots. It is well worth noting that the performance evaluation criterion of both configurations was identical, while surely the heat transfer regarding to the counter flow configuration was higher than its counterpart which was due to a higher temperature difference. The above-mentioned performance evaluation criterion (PEC) is the comparison of heat transfer coefficients between the enhanced tube and smooth tube under the same pumping power condition.

Dizaji et al. (2018) did an experimental study of heat transfer and pressure drop of corrugated tubes in a DPHE which turned out to perceive much importance in the field (Fig.1). Both inner and outer tubes were corrugated in concave and convex shapes. Working fluids in the experiments were hot and cold water which flowed in the inner and outer tube of the heat exchanger, respectively. Research findings showed that the highest effectiveness was obtained for a case when the inner tube and the outer tubes had the convex and concave corrugated configurations, respectively.

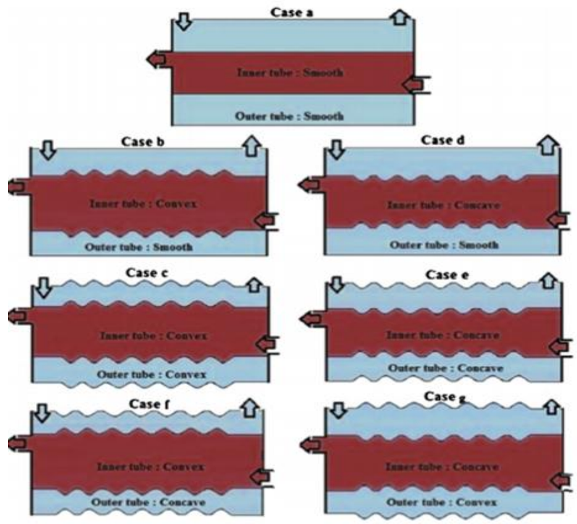

Fig. 1: Different corrugated tubes in a DPHE

Bhadouriya et al. (2018) investigated heat transfer and pressure drop of a DPHE both experimentally and numerically in which the major objective was the effect of twist ratio of the inner tube on the flow characteristics (Fig. 2). A uniform wall temperature at the inner wall of annulus was a boundary condition for the outer flow. Working fluids in the experiments were water and air which flowed in the inner (square duct) and the annulus of the heat exchanger, respectively. The results showed that this geometry change led to an increase in heat transfer rate and pressure drop in all flow regimes. The results of the present paper will help the engineers design more compact heat exchangers. It was also concluded that, unlike smooth tube, Nusselt number in the laminar flow regime was dependent on the flow characteristics and physical parameters such as Reynolds number and twist ratio.

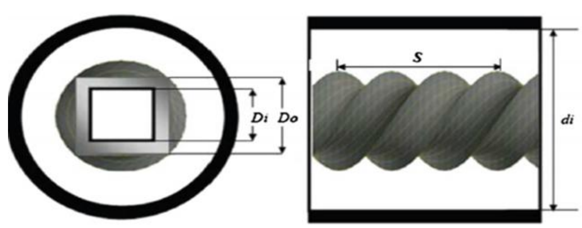

Fig. 2: Twisted inner tube of the DPHE

3. DOUBLE PIPE HEAT EXCHANGER

A double pipe heat exchanger (also sometimes referred to as a 'pipe-in-pipe' exchanger) is a type of heat exchanger comprising a 'tube in tube' structure. As the name suggests, it consists of two pipes, one within the other. One fluid flows through the inner pipe (analogous to the tube-side in a shell and tube type exchanger) whilst the other flows through the outer pipe, which surrounds the inner pipe (analogous to the shell-side in a shell and tube exchanger).
A cross-section of a double pipe exchanger would look something like this: figure 3.
They often have a U-tube structure to accommodate thermal expansion of the tubes without necessitating expansion joints, as illustrated below: figure 4.

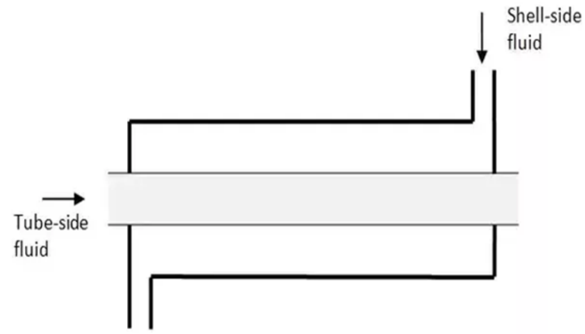

Fig. 3: Double pipe heat exchanger

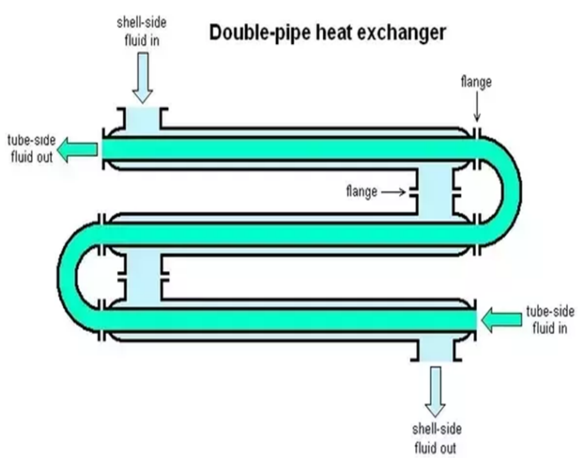

Fig. 4: U-type double pipe heat exchanger

They are one of the simplest and cheapest types of heat exchanger. They can be used for high temperature, high pressure, and highly viscous service.
One of the most simple and applicable heat exchangers is double pipe heat exchanger (DPHE) (Fig. 4). This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Upon having a relatively small diameter, many precise researches have also held firmly the belief that this type of heat exchanger is used in high-pressure applications. They are also of great importance where a wide range of temperature is needed. It is also well documented that this kind of heat exchanger makes a significant contribution to pasteurizing, reheating, preheating, digester heating and effluent heating processes. Many of small industries also use DPHEs due to their low cost of design and maintenance. As a result, we came to conclusion that the previous researches carried out on this type of heat exchanger should be categorized in order to overcome the perplexities of choosing the most appropriate methods of interest.

4. HEAT TRANSFER AUGMENTATION TECHNIQUES

Heat transfer augmentation techniques are generally classified into three categories namely: Active techniques, Passive techniques and Compound techniques.

1. Active Techniques: Active techniques involve some external power input for enhancement of heat transfer.
2. Example: Mechanical aids, Surface vibrations, Fluid vibrations and Jet impingement.
3. Passive Techniques: Passive techniques do not require any direct input of external power. They generally use geometrical or surface modifications to the flow channel by incorporating inserts or additional devices. Example: Rough surfaces, extended surfaces, Swirl flow devices and Coiled tubes.
4. Compound Techniques: Combination of active and passive techniques may be employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by any of those techniques separately. This simultaneous utilization is termed compound enhancement.

5. CONCLUSION

In this review, the development procedure that this type of heat exchanger went through has been analyzed in details and the heat transfer enhancement methods in aforementioned heat exchangers have also been widely discussed. Having also tried the best to present a comprehensive research, the authors gathered information regarding the usage of these methods such as active, passive and compound methods which is worth noting that the studies concerning using passive methods in double pipe heat exchangers have been frequently cited. In this work thermal performance of DPHE with straight and helical fins have been investigated. Firstly the straight and helical fins have been increased from 10 to 12 fins and after that thermo hydraulic performance of DPHE have been investigated.

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