Experimental Performance of Double Pipe Heat Exchanger with Bended Strips: A Review

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Abstract* - A variety of methods for achieving improved heat transfer are usually referred to as "heat transfer augmentation". The heat transfer enhancement techniques are performed in widespread applications. The objective is to reduce as many of the factors as possible: Capital Cost, Power Cost, Maintenance Cost, Space and Weight, Consistent by means of safety and reliability. Present work describes the principal techniques of industrial importance for the augmentation of single phase heat transfer on the inside of tubes namely "Bended strip''. So Bended strips should be used in heat exchanger when high heat transfer rate is required and pressure drop is of no significance. In this case the heat transfer rate can be improved by introducing a disturbance in the fluid flow by heat enhancement technology by using bended strips. Bended strips of varying pitches ranging from 10mm, 15mm, 20mm and 25mm respectively inserted in the inner tube.

***Keywords* - Heat Exchanger, Bended strips, different range, Reynolds number**

1. INTRODUCTION

Heat exchangers are devices that facilitate the exchange of heat energy between two fluids that are at different temperatures while keeping them from mixing with each other. Heat exchangers are used in different processes ranging from conversion, utilization & recovery of thermal energy in various industrial, commercial & domestic applications. Some common examples include steam generation & condensation in power & cogeneration plants; sensible heating & cooling in thermal processing of chemical, pharmaceutical & agricultural products; fluid heating in manufacturing & waste heat recovery etc. Increase in Heat exchanger's performance can lead to more economical design of heat exchanger which can help to make energy, material & cost savings related to a heat exchange process. The development of high performance thermal systems has stimulated interest in methods to improve heat transfer. The need to increase the thermal performance of heat exchangers, thereby effecting energy, material & cost savings have led to development & use of many techniques termed as Heat transfer Augmentation. These techniques are also referred as Heat transfer Enhancement or Intensification. Augmentation techniques increase convective heat transfer by reducing the thermal resistance in a heat exchanger. Heat transfer enhancement or augmentation techniques refer to the improvement of thermo-hydraulic performance of heat exchangers. Existing enhancement techniques can be broadly classified into three different categories:

- Passive Techniques
- Active Techniques
- Compound Techniques

2. PREVIOUS WORK

Yang Ru et.al [1] presents the experimental studies of double pipe heat exchanger with the curves inner tube. Curved-pipe curvature induces a secondary flow across the main stream that may enhance heat transfer rate significantly. Experiments are made for measuring the heat transfer and the pressure drop for water flow inside a wavy curved-pipe. It is found that the heat transfer rate may be increased by up to 100%, as compared with a straight pipe, while the friction coefficient increased by less than 40%.

Shahiti N. et.al [2] presents the experimental study of heat transfer and pressure drop characteristics of a double-pipe pin fin heat exchanger. The author develops the mathematical model of the entropy generation minimization for different heat exchanger flow lengths and different pin length.. It could be demonstrated that for all the investigated flow length, an optimal region Re, which ensures a minimal NS, could be found. Furthermore, based on the empirical correlations used for heat transfer and pressure drop .it could be shown that shorter flow lengths are accompanied with lower entropy production rates, and hence these would be thermodynamically preferable. Hence, it can be concluded that no single optimal flow length exist, but this should be as smaller as possible taking into consideration the heat exchanger duty and the available frontal area.

Siddique Mansoor et.al [3] presents the experimental investigation of double pipe heat exchanger with water as the cooling as well as the heating fluid for six sets of runs. The pressure drop data is collected under isothermal conditions. Data were taken for turbulent flow with $3300 \le Re \le 22{,}500$ and $2.9 \le Pr \le 4.7$. The main focus of the present study is to experimentally investigate the heat transfer and the pressure drop characteristics of a typical micro-fin tube and to develop accurate, simple and easy to use empirical design correlations for turbulent flow conditions in the range 3300 $\leq$Re $\leq$ 22,500.

Zhang Li et.al [4] presents the study on double-pipe heat exchanger with helical fins and pin fins. LDA measurements are performed on the flow in helical shell sides of double-pipe heat exchanger with and without pin fins under the cylindrical coordinate system. The behaviors of the fluid flow in the shell sides with and without pin fins are studied under orthogonal helical coordinate system. For the shell side only with helical fins, the maximum axial velocity region occurs near the outer wall of the channel. The secondary flow retains a two-vertex structure counter-rotating; and the upper vortex is small and the lower vortex is large as the pitch in the present work is large.

Promvonge Pongjet et.al [5] experimentally investigated the turbulent convective heat transfer characteristics in a helical-ribbed tube fitted with twin twisted tapes. Thermal characteristics in a helical-ribbed tube fitted with twin twisted-tapes in co-swirl arrangement are presented in the present study. The work has been conducted in the turbulent flow regime, Re from 6000 to 60,000 using water as the test fluid. The experiment was carried out in a double tube heat exchanger using the helical-ribbed tube having a single rib-height to tube-diameter ratio, e/DH= 0.06 and rib-pitch to diameter ratio, P/DH= 0.27 as the tested section. The insertion of the double twisted tapes with twist ratio, Y, in the range of 2.17 to 9.39 is to create vortex flow inside the tube. The results of work show that, for the inserted ribbed tube, the Nu tends to increase with the rise in Re while the f and TEF give the opposite trends.

Ho Chii-Dong et.al [6] presents the work on efficiency improvement in heat transfer through double-pass concentric circular tubes with an impermeable sheet of negligible thermal resistance to divide a circular tube into two sub channels with uniform wall temperature and external refluxes at the ends. It has been investigated and solved analytically by the use of the orthogonal expansion technique with the Eigen function expanding in terms of an extended power series. The method for improving the performance in a concentric circular double-pass heat exchanger is presented in this study.

Iqbal Z. et.al [7] presents the optimal configurations of finned annulus with parabolic fins have been investigated for maximum convection by employing trust-region and genetic algorithms. Flow is considered to be steady, laminar, incompressible and fully-developed subjected to constant heat flux boundary condition. Finite element method is employed to compute field variables for providing function values to the optimizers. Using Nusselt number as objective function various optimal configurations have been proposed depending on practical and industrial requirements. The present study leads to conclusion that, the thicker fins augmented to the outer surface of an inner pipe of as smaller a radius as possible give optimal Nusselt number.

SwameePrabhata K. et.al [8] presents the optimal design of the exchanger has been formulated as a geometric programming with a single degree of difficulty. The solution of the problem yields the optimum values of inner pipe diameter, outer pipe diameter and utility flow rate to be used for a double pipe heat exchanger of a given length, when a specified flow rate of process stream is to be treated for a given inlet to outlet temperature. Author has explained the optimal design procedure .

Behabadi M. A. Akhavan et.al [9] presents the experimental investigation has been carried out to study the enhancement in heat transfer coefficient by coiled wire inserts during heating of engine oil inside a horizontal tube in a laminar flow heat exchanger. In present experimentation two different coiled wire insert of 2.0 mm and 3.5 mm wire thickness are used and test-section was a double pipe counter-flow heat exchanger. The engine oil flowed inside the internal copper tube; while saturated steam, used for heating the oil, flowed in the annulus. The effects of Reynolds number and coiled wire geometry on the heat transfer augmentation and fanning friction factor were studied. The present study leads to conclusion that, coiled wire insert of 2.0 mm wire thickness enhances the oil side Nusselt number, while the coiled wire pitch has a little effect on the Nusselt number. The insert enhances the Nusselt number by 2.2 times than that of the plain tube. However, for the coiled insert of 3.5 mm wire thickness, the enhancement in Nusselt number can be attained up to 3.2 times.

NaphonPaisarn et.al [10] presents the heat transfer characteristics and the pressure drop of the horizontal double pipes with and without coiled wire insert are investigated. the heat transfer rates obtained from micro-fin tube with coiled wire insert are higher than those from micro-fin tube without coiled wire insert. The results of work show that the average tube-side heat transfer coefficient increases with increasing hot water mass flow rate. In addition, at the same conditions, the average tube-side heat transfer coefficients obtained from the micro-fin tube with coiled wire insert are the highest as compared with those from the smooth tube and the micro-fin tube without the coiled wire insert.

Eiamsa-ard Smith et.al [11] Its present work experimentally investigates the heat transfer and friction characteristics in double pipe heat exchanger by inserting louvered strips. The turbulent flow devices consist of the louvered strips with forward or backward arrangements, and the louvered strip with various inclined angles (θ=15°, 25° and 30°), inserted in the inner tube of the heat exchanger. The result obtained from experimentation such that, Louvered strip insertions can be used efficiently to augment heat transfer rate because the turbulence intensity induced could enhance the heat transfer. The highest heat transfer rate was achieved for the backward inclined angle of 30° due to the increase of strong turbulence intensity

Feng-Xiang Li et.al [12] present experimentation study on laboratory investigation and commercial test for smooth tube inserted with rotors-assembled strand comparing with non-inserted ones on condensers in electric power plant, using water as working fluid. The single-phase pressure drop and heat transfer were measured. Difficulties are found to receive reliable and accurate enough data through commercial test. Meanwhile, the single-phase pressure drop and heat transfer in a rotors-assembled strand inserted tube were measured in laboratory, with the tube side Prandtl numbers varying from 5.67 to 5.80 and the tube side Reynolds numbers varying from 21,300 to 72,200. Before that, a validation experiment based on the same smooth tube was carried out to testify the experimental system and the data reduction method, in which fixed mounts were employed to eliminate entrance effects. The Prandtl numbers varied from 5.64 to 5.76 and the Reynolds numbers varied from 19,000 to 56,000 in the tube. The annular side Reynolds numbers remained nearly constant at the value of around 50,000 for all experiments, with the annular side Prandtl numbers varying from 8.02 to 8.22[c] .

YildizCengiz et.al [13] presents its works experimental investigation is carried out on influence of fluid rotation on the heat transfer and pressure drop in double pipe heat exchanger. In its experimental work, propellers are placed inside the inner pipe of double pipe heat exchanger and they are freely rotated due to force exerted by fluid flowing inside the inner tube. The experiment was carried out for Reynolds number in the range of 2500 to 15000 and for several propellers. From this study the results obtained such that, the heat transfer rate in double pipe heat exchanger may be increased up to 250% by giving rotation to the fluid with the help of propellers.

Murugesan P. et.al [14] experimentally investigated, the effect of V cut twisted tape insert on heat transfer, friction factor and thermal performance factor characteristics in a circular tube were investigated for three twist ratios (y=2.0, 4.4 and 6.0) and three different combinations of depth and width ratios (DR=0.34 and WR=0.43, DR=0.34 and WR=0.34, DR=0.43 and WR=0.34).and compared with without V cut twisted tape insert.The result obtained from this experimental investigation such that The V-cut twisted tape offered a higher heat transfer rate, friction factor and also thermal performance factor compared to the plain twisted tape. In addition, the influence of the depth ratio was more dominant than that of the width ratio for all the Reynolds number.

Tijing Leonard D. et.al [15] presents its study on investigation of effect of internal aluminum fins with a star-shape cross-section on the heat transfer enhancement and pressure drop in a counter flow heat exchanger. A concentric-tube heat exchanger was used with water as the working fluid. Based on the results, it is concluded that, the overall heat transfer coefficient in a concentric-tube heat exchanger was enhanced with a star-shape fin insert by as much as 51% at a constant pumping power. The percentage increase in the pressure drop was larger than the percentage increase in the heat transfer rate, in general. When compared with the similar data reporting heat transfer enhancements with inserted devices, the present study showed a fair performance .A better heat transfer enhancement and lesser pressure drop could be achieved by making the fin thickness smaller so as to reduce flow restriction while maintaining a large surface area.

3. PROPOSED METHODOLOGY

The experimental set-up used in the present study. The test section is a tube in tube heat exchanger. An experimental apparatus is conducted to study the heat transfer performance and friction factor in a tube with bended strips inserts. It is composed of cold water tank, hot water tank, temperature sensors, flow control valve, temperature display, mono block pump, thermostatic water heater, annulus and four different geometries of bended strips.

A double pipe heat exchanger is utilized as the main heat transfer test section which is insulated using asbestos to minimize heat loss to the surrounding. It consists of two concentric tubes in which hot water flows through the inner tube and cold water flows in counter flow through annulus. The outer tube made of a stainless steel having inside and outside diameters of 23.5 mm and 25 mm respectively. The inner tube made of a cupper having inside and outside diameters of 11 mm and12.5 mm respectively. It has a heat transfer section of a length of 1.25m. In the experimentation, the various bended strips having different pitch 10, 15, 20, 25 and plain tube with the central axis of the inner tube are inserted inside the inner tube. The inserted strips create turbulence inside the inner pipe which enhances the heat transfer rate.

The two flow meters are used to maintain shell side and tube side mass flow rates of water. The working range of flow meter is from 0.003kg/sec to 0.024kg/sec. The two FCV is used to controlled tube side and annulus side mass flow rate. One flow meter used to measure hot water mass flow rate and another flow meter is to measure annulus side cold-water mass flow rates. A PT100 type temperature sensor is directly inserted into inner and outer tube to measure inlet and outlet temperatures of both the fluids. Temperature data was recorded using data acquisition/switch unit.

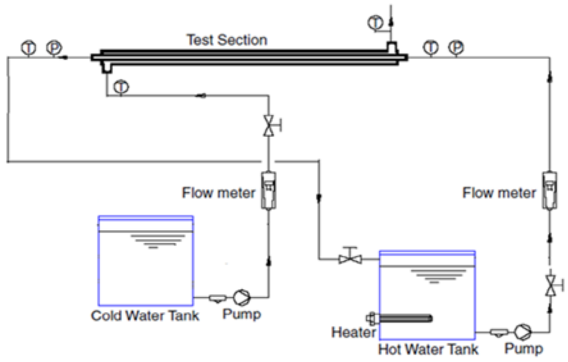

Fig .1 Experimental set-up

A schematic diagram of the experimental apparatus is shown in Fig.1 it consists of a test section, hot water tank, and cold water tank and data acquisition system. The details of the double fined tube heat exchanger are shown in Fig. 2. The close-loops of hot and cold water consist of the electric heaters controlled by adjusting the temperature. Water is used as the medium for cooling the hot water. The hot water is adjusted to the desired level and controlled by a temperature controller. The temperatures of the cold and hot water are adjusted to achieve the desired level. The water and tube wall temperatures at the inlet, middle and outlet sections are measured by four K type thermocouples.

4. CONCLUSION

Experimental study of Double pipe heat exchanger will performed using four different patterns of bended strips with varying pitch such as 10mm, 15mm, 20mm, and 25mm respectively. The effect these strips of given pitch on the heat transfer enhancement and friction factor behaviors in flow regimes of Reynolds Number are described. The bended strips of given pitch will tested for counter flow configuration using water as working fluid with single phase heat transfer are studied . The effects of parameters such as pitch, Reynolds number on the heat transfer and overall enhancement ratio are studied.

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