Study of Heat Transfer Rate in Counter Flow Heat Exchanger using V Shaped Aluminum Wire Roughness: A Review

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Abstract— Counter flow Heat Exchanger is more effective heat exchanger than the other, it is widely used for increasing the heat transfer rate than other kind of exchanger. In many engineering application like refrigeration system, air conditioning system, power system, chemical rector, and many industrial and space aeronautical applications heat exchanger are used. For the effective performance and application of heat exchange, it is very essential to increase heat rate through it. So the interest of researchers has been directed toward for enhancing heat transfer rate and improve thermal hydraulic performance, by using different type of roughness techniques such as tapered twisted tape, micro channel, spiral coil shaped roughness. Researchers were also focused on increasing turbulence 8000-15000 for enhancing heat rate using roughness on tube or plates. In addition, researchers used a parameter for study with respect to the rib length ratio, rib pitch ratio, and rib inclination angle was conducted to optimize the geometric configuration of the ribs and improve heat enhancement and friction factor. A literature survey of research that, this is an essential area of research, and the main focus of present article seeks to provide comprehensive review of previous and recent research work published on enhancing heat transfer rate.

Key words: Heat Exchanger, Heat Transfer Enhancement, Roughness, Turbulence, Friction Factor

I. INTRODUCTION

Heat exchanger are the devices that are used for the exchange heat between two fluids that are at different temperature. Heat transfer take place by convection in each fluid and by conduction through the wall which is used for the separation of the two fluid. Heat transfer rate between two fluids is depend on the temperature difference of the fluids. There are some types of the heat exchanger.

A. Parallel flow

In parallel flow both hot and cold fluids enter the heat exchanger at the same end and move in the same direction.

B. Counter flow

In counter flow both hot and cold fluids enter the heat exchanger in the opposite end and flow also in the opposite direction.

C. Cross flow

In cross flow usually the both hot and cold fluid flow in perpendicular direction, cross flow have also mixed and unmixed flow, in unmixed flow fluid flow through a particular space. While in mixed flow fluid is free to move in transverse direction.

There are also some methods are:

1) Active method

It involved some external power input to bring about the desired flow.

2) Passive method

In that method does not need any external power input and the additional power needed to enhance the heat transfer is taken from the available power in the system.

3) Compound method

A compound method is a hybrid method in which both active and passive methods are used in combination.

II. LITERATURE REVIEW

L. Cheng [1] the flow-induced vibration in heat exchanger is usually considered as a detrimental factor for causing the heat exchanger damage and is strictly prevented from its occurrence. Its positive role for the possible heat transfer enhancement has been neglected. In this article a novel approach is proposed to enhance the heat transfer by using the flow-induced vibration of a new designed heat transfer device. Thus the flow-induced vibration is effectively utilized instead of strictly avoiding it in the heat exchanger design.

A heat exchanger is constructed with the new designed heat transfer devices. The vibration and the heat transfer of these devices are studied numerically and experimentally, and the correlation of the shell-side convective heat transfer coefficient is obtained. It is found that the new designed heat exchanger can significantly.

S. Tabatabaeikia [2] Heat transfer enhancement has been always a significantly interesting topic in order to develop high efficient, low cost, light weight, and small heat exchangers. The energy cost and environmental issue are also encouraging researchers to achieve better performance than the existing designs. Two of the most effective ways to achieve higher heat transfer rate in heat exchangers are using different kinds of inserts and modifying the heat exchanger tubes. There are different kinds of inserts employed in the heat exchanger tubes such as helical/twisted tapes, coiled wires, ribs/fins/baffles, and winglets. This paper presents an overview about the early studies on the improvement of the performance of thermal systems by using different kinds of inserts. Louvered strip insert had better function in backward flow compared to forward one. Modifying the shape of twisted tapes led to a higher efficiency in most of the cases except for perforated twisted tape and notched twisted tape. Combination of various inserts and tube with artificial roughness provided promising results. In case of using various propeller types, heat transfer enhancement was dependent on higher number of blades and blade angle and lower pitch ratio.

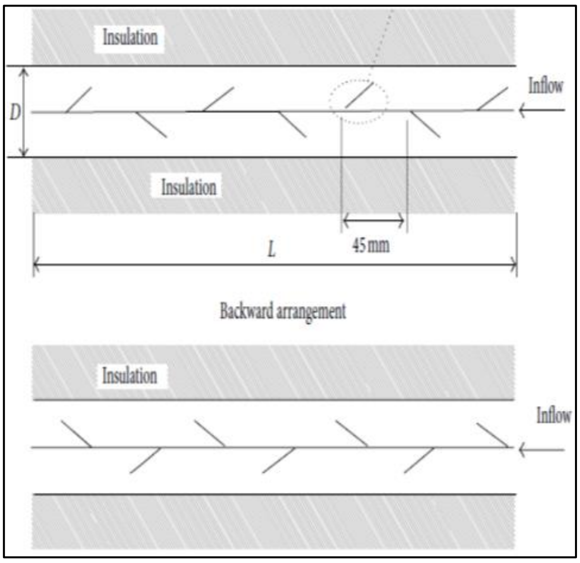

Fig. 1: Forward and Backward Arrangements of louvered Strips

SombatTamna [3] an experimental work on heat transfer enhancement in around tube by insertion of double twisted tapes in common with 30° V shaped ribs has been conducted. Air as the test fluid flowed through the test tube having a constant wall heat flux with Reynolds number (Re) from 5300 to 24,000. The combined vortex generators (called ribbed twisted tape") were obtained by in corpora ting V shaped ribs in to the edge so double co twisted tapes having a similar twist ratio f4. The effect of pertinent V-rib parameters such as four relative rib heights , (called "blockage ratio" , BR ¼ b/D ¼ 0.07 ,0.09 ,0.14 and 0.19)and are lativerib pitch, (PR¼ P/D¼ 1.9) a tan attack angle of rib, α¼30° on thermal characteristics was investigated .The experimental results reveal that the heat transfer and pressure drop in term so f the respective Nusselt number and friction factor for the V ribbed twisted tapes show the increasing trend with the rise of Read BR. The v ribbed twisted tape with BR¼ 0.19 yields the highest heat transfer and friction factor. However, the maximum thermal enhancement factor is about 1.4 for the V-ribbed twisted tape at BR¼ 0.09 but is around 1.09 for the twisted Tape with no rib.

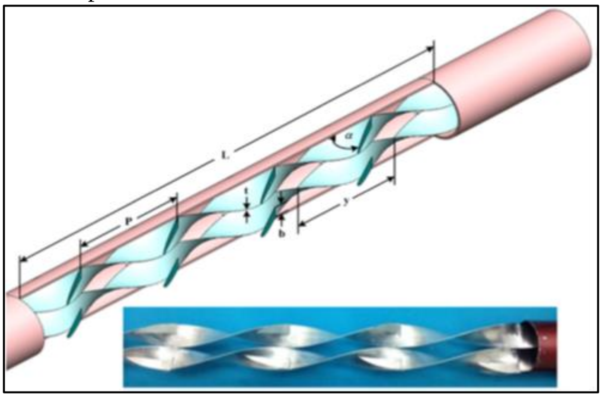

Fig. 2: Dimensions of V-ribbed twisted-tapes.

Amar Raj Singh Suri[4] an experimental study on Nusselt number and friction factor of heat exchanger circular tube fitted with multiple square perforated with square wing twisted tape inserts. The experimental determination encompassed the geometrical parameters namely, wing depth ratio (w_d/w_t) of 0.042–0.167, perforation width ratio (a/W_T) 0.250, twist ratio (T_L/W_L) of 2.5, and number of twisted tapes (N) of 4.0. The effect of multiple square perforated twisted tapes with square wing has been investigated for the range of Reynolds number (Re_n) varied from 5000 to 27,000. The maximum enhancement in Nu_{rs} and f_{rs} is observed to be 6.96 and 8.34 times of that of the plain circular tube, respectively. Correlations of Nu_{rs}, f_{rs} and η_p are established in term.Of Re_n and geometrical parameters of wings twisted tape which can be used to predict the values of Nu_{rs}, f_{rs} and η_p considerably good accuracy.

Fig. 3: Plain Twisted Tape

Zhen Zhang [5] Thermo-hydraulic characteristics of turbulent flow in plain tube equipped with rotor-assembled strands of different geometries and leads were reported, ahead of which an experiment considering a smooth tube had been conducted to calibrate the experimental system and data reduction method. The effects of rotor lead on heat transfer and friction characteristics were emphasized consequently. Experimental results revealed that rotor-assembled strands of different geometries employed improved heat transfer significantly with Nusselt number increased by 71.5–123.1% and friction factor increased by 37.4–74.8% compared with plain tube. There into, the helical blade rotor brought the most augmentation of heat transfer, while the blade-discrete rotor caused the largest friction loss. Generally considering, helical blade rotor with ladders offered first-class performance sequentially followed by helical blade rotor and blade-discrete rotor. For helical blade rotor with ladders, Nusselt number and friction factor both increased with the decrease of rotor lead. The best thermal performance factor was achieved when helical blade rotor with ladders was manufactured with certain parameters (rotor diameter is 22 mm, rotor lead is 150 mm). At last, the correlations of experimental results were presented based on thorough multivariate linear normal regression method.

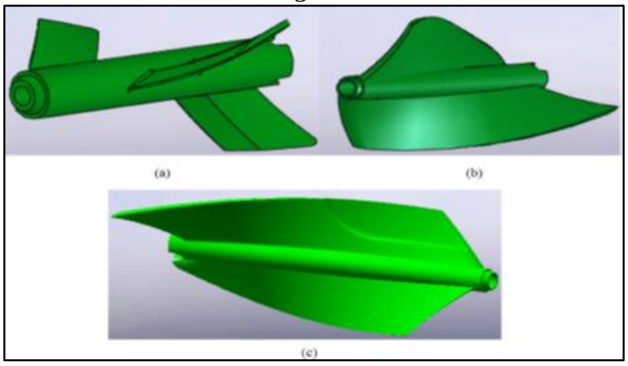

Fig. 4: Rotor-assembled

Nianben Zheng, [6] This paper presents the results of a numerical study on heat transfer enhancement and the flow structure in a heat exchanger tube fitted with discrete double inclined ribs characterized by a discrete and inclined distribution. Water was selected as the working fluid, and Reynolds numbers between 3390 and 20340 were considered. The numerical results show that heat transfer in the ribbed tube was approximately 1.8e3.6 times greater than that in a smooth tube, while the friction factor was approximately

2.1e5.6 times greater. The performance evaluation criterion (PEC) values based on the same pump power were found to vary from 1.3 to 2.3. Visualization of the flow in the ribbed tube showed that three pairs of counter rotating vortices or longitudinal swirl flows were generated inside the tube and that the main stream flow was divided into six helical streams, resulting in a long flow path and relatively intense turbulent mixing between the wall and the core flow regions. In addition, a parameter study with respect to the rib length ratio, rib pitch ratio, and rib inclination angle was conducted to optimize the geometric configuration of the ribs. Based on the optimization results, a rib length ratio of 4, a rib pitch ratio of 5, and a rib inclination angle of 37.5_ are recommended for practical applications.

B.K.P. Ary [7] the effect of a number of inclined perforated baffles on the flow patterns and heat transfer in the rectangular channel with different types of baffles is numerically and experimentally checked out. Reynolds numbers are varied between 23,000 and 57,000. The SST k−ω turbulence model is used in the method to predict turbulent flow. The baffles have the width of 19.8 cm, the square diamond type hole having one side length of 2.55 cm, and the inclination angle of 5°. The results show that the flow patterns around the holes are entirely different with different numbers of holes and it significantly affects the local heat transfer, and two baffles provide greater heat transfer performances than a single baffle.

Pawan Singh Kathait [8] Heat exchangers are omnipresent in every thermal system receiving or rejecting heat with its surroundings. Thermal performance of a system is highly dependent on the heat exchangers ability to transfer heat which is governed by distinct fluid flow characteristics in the tube passages. Use of corrugated tube results in higher heat exchange rates at the cost of additional power lost in friction. In search of thermo-hydraulically superior corrugation geometry, the present study investigates the effect of (modified tube surface) discrete corrugated rib roughened tube on heat transfer and frictional losses under varied fluid flow rates. Heat exchanger tubes having corrugated rib roughness with different number of gaps have been tested for pitch to rib height ratio (P/e) of 6-14 by operating under a wide range of flow Reynolds number (Re) from 7500 to 50,000. The maximum enhancements in Nusselt number and friction factor are found to be 2.73 and 2.78 corresponding to (P/e) of 10, (e/D) of 0.044 for the corrugated tube with five number of gaps. Thermo hydraulic performance parameter (h) lie between1 and 1.76, 1.02e1.82 and 1.05e1.95 for type-1, type-2 and type-3 corrugated tube respectively. Experimental results show that type-3 corrugated tube with (P/e) of 10 is thermo hydraulically superior than other configurations at the flow Reynolds number of 7343.

S. V. ahidifar [9] This study investigates heat transfer characteristics and the pressure drop of a horizontal double pipe heat exchanger with wire coil inserts. The amplification of convection heat transfer coefficient in the heat exchanger reduces the weight, size and cost of heat exchanger. One way of augmenting the heat transfer is to

Disturb the boundary layer. When an object is placed in a boundary layer, it affects the flow structure and alters the velocity and thermal profiles. The change is affected by the formation of jets and wakes in the boundary layer as it alters modifies transfer and friction coefficients on the wall. This paper studies the characteristics of the heat transfer and the pressure drop of a double pipe horizontal tube heat exchanger with an inserted wire coil and rings. Wire coil acts as a swirl flow, which increases turbulence and roughness whereas rings increase heat transfer as a promoter of turbulence and roughness. The experimental data sets were extracted from wire coils and rings tested within a geometrical range with a pitch of (P/D=1, 2, 4) and wire diameter of (d/D=0.05, 0.07, 0.11). For wire coil with d/D=0.11, P/D =1 and Reynolds number of10000, the overall enhancement efficiency amounted to 128%..

Li Xiao-wei [10] the mechanism of turbulent convective heat transfer enhancement was experimentally investigated by measuring the heat transfer in two dimensional roughness tubes with different roughness heights at various Reynolds numbers. The results show that there is a maximum Nusselt number ratio (Nu/Nu0) for a fixed roughness height with increasing Reynolds numbers. For water as working fluid, heat transfer can hardly be increased when the roughness height is lower than the thickness of the viscous sub layer, and both heat transfer and flow friction begin to increase when the roughness height is higher than the viscous sub layer. When the roughness height is more than five times of the viscous sub layer thickness, the flow friction begins to increase sharply but heat transfer is slowly enhanced. So the best heat transfer enhancement for a given pumping power is reached when the roughness height is about three times of the viscous sub layer thickness. The Prandtl number influences to the turbulent heat transfer enhancement by roughness were also analyzed.

Conclusion

As the literature we found that there are several types of methods are used for enhance the heat transfer rate and turbulence used different types and different shapes. Roughness different types such as ribs, wire coil, twisted tape, baffles, Rotor. Also used shape such as in a discrete, twisted, ring shape with different flow pattern. For that turbulent flow is more efficient than laminar flow Study of literature there is no research found on counter flow heat exchanger by using v shape aluminum wire roughness for enhance the heat transfer. Since aluminum V shape improve the additional turbulence .there are some imported terms also considered Friction factor, overall heat transfer coefficient, different- different pitch, which also effect on mass flow rate and heat transfer effect.

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