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Experimental Investigation of Heat Transfer Enhancement in Tube in Tube Heat Exchanger with Perforated Twisted Tapes

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Abstract: This article reports an experimental investigation on heat transfer and pressure drop characteristics of turbulent flow in a heating tube equipped with perforated twisted tapes for Reynolds flow rate 1 to 8 LPM. The parameters investigated were the hole diameter ratio (d/W = 0.2, 0.4 and 0.6) and depth ratio (w/W = y/w=2.5, 3.5 and 4.5). A typical twisted tape was also tested for an assessment. Compared to the plain tube, the tubes with TT and PTT heat transfer enhancement up to 168% and 226%, respectively. The evaluation of overall performance under the same pumping power reveal that the PTT with d/W = 0.4 and y/W = 4.5, gave the maximum thermal performance factor of 1.62, as compare to plain tube.

Keywords: Twisted Tapes, Perforated Twisted Tapes, Performance Criteria, Friction Factor.

I. INTRODUCTION

Effective utilization of available energy becomes need of hour today. This obviously requires effective devising. When it concerns heat energy the devices are heat exchangers. Heat exchangers are used in variety of applications. Heat exchangers are commonly used in automotive, air conditioning, oil refineries and other large-scale chemical processes. Increase in Heat exchanger 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.

Several design parameters and operating conditions influence the optimal performance of a heat exchanger. Past studies have shown that the flow in the heat exchanger is strongly dependent on geometrical parameters. By manipulating the geometrical parameters of the chamber, we can obtain a heat exchanger with maximum heat transfer coefficient within allowable design limit. The goal of enhanced heat transfer is to encourage or accommodate high heat fluxes. The need to increase the thermal performance of heat exchangers, thereby effecting energy, material and cost savings have led to development and 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.

Artificially roughened surfaces, extended surfaces, vibration of the surface or fluid, application of electrostatic fields, inlet vortex generators and the insertion in tubes of objects such as twisted tapes, coiled wire or spinners are a few examples of such augmentative techniques. Existing systems can often be improved by using an augmentative method, while in other applications, such as the design of heat exchangers for use in space vehicles, an augmentative scheme may be mandatory in order for the system to function properly and meet the size limitations imposed. Increases in cost, weight, and pumping power are frequently associated with a given augmentative method, and the designer must, therefore, make a careful study in order to determine the net improvement available from such a method.

A. Heat Transfer Augmentation Techniques

“Heat transfer Augmentation” means Increase in Heat exchanger’s performance with the Help of augmentation techniques, this can lead to more economical design of heat exchanger. These augmentation techniques in general are classified into Passive, Active and Compound techniques.

Active techniques: This method involves some external power input for the enhancement of heat transfer.

Passive techniques: This method generally uses surface or geometrical modifications to the flow channel by incorporating inserts or additional devices.

Compound techniques: A compound augmentation technique is the one where more than one of the above-mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger.

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II. LITERATURE SURVEY

The heat exchanger plays an important role in almost all of the mechanical industries and especially in case of process industries it is an key element. 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. Thus, from long time many researchers in this area are working to improve the performance of these heat exchangers in terms of heat transfer rate, keeping pressure drop in limit. In order to augment heat transfer and to increase thermal performance of the heat exchangers, heat transfer enhancement techniques are widely used. 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 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 classified in three groups, active, passive and compound techniques.

P. Eiamsa-ard, et al. [1] In this paper, the effects of regularly spaced twisted tape is analysed by comparing it with the full length twisted tape and plain tape. The twisted tapes used are of different pitches. Numerical simulation is used to visualize the flow. The experiment results show that heat transfer rate and friction increased with decreasing twist ratio and space ratio. The full length twisted tapes found to be more useful than regularly spaced tapes from the thermal performance point of view.

S. Naga Sarada et. al. [2] This experiment work shows the results obtained from experimental investigations of the augmentation of turbulent flow heat transfer in a horizontal tube by means of varying width twisted tape inserts with air as the working fluid. In order to reduce excessive pressure drops associated with full width twisted tape inserts, with less corresponding reduction in heat transfer coefficients, reduced width twisted tapes are used. Experiments were carried out for plain tube with/without twisted tape insert at constant wall heat flux and different mass flow rates. Both heat transfer coefficient and pressure drop are calculated and the results are compared with those of plain tube. It was found that the enhancement of heat transfer with twisted tape inserts as compared to plain tube varied from 36 to 48% for full width (26mm) and 33 to 39% for reduced width (22 mm) inserts. Correlations are developed for friction factors and Nusselt numbers for a fully developed turbulent swirl flow, which are applicable to full width as well as reduced width twisted tapes.

A.Rahul kumar et. al. [3]The objective of this paper is to investigate the swirl flow behavior and the laminar convective heat transfer in a circular tube with twisted-tape inserts. The fluid flow and thermal fields are simulated computationally in an effort to characterize their structure. Apart from this, issues like long term performance & detailed economic analysis of heat exchanger has to be studied to achieve high heat transfer rate in an existing or new heat exchanger while taking care of the increased pumping power. It was concluded from the experiment that for same twist ratio, twisted tape shows higher heat transfer coefficient & friction factor increase because of higher degree of turbulence created.

W.H.Azmi et. al. [4] This paper covers the experimental determination of heat transfer coefficients of SiO_2/water and TiO_2/water nanofluid up to 3% volume concentration flowing in a circular tube. The investigations are conducted in the Reynolds number range of 5000 to 25000 at a bulk temperature of 30 Deg C. The experiments are undertaken for flow in a circular tube with twisted tapes of different twist ratios in the range of $5< H/D< 93$. It was found that the heat transfer enhancement is inversely increased with twist ratio. The heat transfer coefficient of SiO_2/water nanofluid at 3.0% volume concentration is 27.9% higher than water flow for the same twist ratio of five. However, the value of heat transfer coefficient of TiO_2/water nanofluid evaluated at the same concentration is 11.4% greater than water for twist ratio five. Regression equations for Nusselt number estimation are developed valid for water and nanofluid flow with twisted tape inserts under turbulent flow conditions.

A.V.Gawandare et. al. [5] The present experimental work is carried out with copper twisted tape inserts 3mm with different twists respectively. The work includes the determination of friction factor and heat transfer coefficient for various twisted wire inserts with varying twists and different materials. Correlations for Nusselt number and friction factor are developed for the twisted wire inserts from the obtained results. The results of varying twists in square jagged tape with different pitches have been compared with the values for the smooth tube. The 3mm thick with 3.2 twists copper insert shows increase in Nusselt number values by 76% however there is increase in friction factor by only 19.5% as compared to the smooth tube values.

A. E. Zohir [6] In this paper, heat transfer haracteristics and pressure drop are studied for turbulent flow in a sudden expansion pipe equipped with propeller swirl generator. The experiments are performed for vaying Reynolds number for three locations for the propeller fan upstream the sudden expansion and three locations downstream the sudden expansion. Use of propeller at downstream gives better result than at upstream. Correlations for Nusselt number and thermal performance are presented for different fan locations and different Reynolds number.

S Eiamsa-ard et. al. [7] Here the combination of twisted tape and helical screw tape is used for generating swirl flow. The two tapes are arranged in co-swirl and counter swirl arrangement. Initially both the tapes are testes alone for

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benchmark analysis and then combination of these two tapes is studied. The results show the combined tapes method gives 10% higher thermal performance than the single tape method.

Yu. A. Kuzma-Kichta et. al. [8] In this paper, the results of investigation of heat-transfer enhancement in tubes with two-thread screw knurling are presented. The analysis of heat-transfer enhancement in tubes with double-thread screw knurling leads to the following ranges of parameters, in which optimal intensification of heat transfer is ensured: 7000 < Re < 30000 and 2.5 < t < 12. Screw knurling can be performed with different numbers of threads, which is determined by the requirements of the heat-transfer and pressure drop growth rates.

Many researchers have been carried out experimental studies for improvement in heat transfer by using twisted tapes insert. Agrawal et. al. [9] conducted an experiment study to determine the characteristic of friction and heat transfer for heating and cooling of Servotherm oil under uniform wall temperature with twisted tapes inserts. In experiment two double pipe heat exchangers is used, one pipe for hot and other is for cold in series. The prediction of isothermal friction factor and Nusselt number is given by new correlation for uniform wall temperature of viscous liquids when twisted tapes of twist ratio is less than or equal to 5. The results showed a growth in isothermal friction factor which was 3.13–9.71 times the values of plain tubes whereas at constant pumping power and constant flow rate increase in Nusselt number were found to be 1.21–3.70 and 2.28–5.35 respectively times the plain tube values. The relationship was developed to predict isothermal friction factor for (Re/y) ¼ 9-1000.

Al-Fahed et. al. [10]carried out an experimental investigation to study the effect of clearance between tube and tape on heat transfer characteristics for fully developed turbulent flow through a horizontal isothermal tube. The experimentation is conducted for fifteen different twisted tapes. 3.6, 5.4 and 7.1 these three different twist ratios were selected with five different widths of 10.8 mm, 11.4 mm, 12.0 mm, 12.6 mm and 13.2 mm. The results showed that with decrease in tube- tape clearance the enhancement of heat transfer rate increases. Result Also shows that, for twist ratio 3.6 and tape width 10.8 mm, heat transfer enhancement was nearly equal to 13.2 mm width of same twist ratio. Almost 17% difference in heat transfer enhancement was obtained from different widths with twisted tape of twist ratio 3.6, and same difference in heat transfer improvement for twisted tapes of twist ratio 5.4 and 7.1 was 9% and 5% respectively. The study concluded that with small twist ratio and tight fit tape are desirable to achieve high heat transfer improvement for turbulent flow in practical design of thermal systems.

Al-Fahed and Chamra L.M. [11]conducted an experimental study to study and compare heat transfer coefficients and pressure drop for a plain, twisted tape inserts and microfin in laminar flow region. By using a single shell and tube heat exchanger tThe experiments were performed, were steam as a heating source and oil was used as a working fluid. The twisted tapes of three different twist ratios 3.6, 5.4 and 7.1 for and two widths ratio 0.95 and 0.77 were selected in the study. The study shows that from the results that the use of twisted tapes is most effective method to improve heat transfer rate. It was also found that heat transfer rate increases with decreasing twist ratio. Higher values of heat transfer were obtained by using tight fit tapes for twist ratios 3.6 and 5.4 than loose fit tapes. But the high heat transfer rate was obtained by loose fit tapes than tight fit tapes for twist ratio of 7.1. The comparison of friction factor of microfin tube with that of plain tube was done using Friction Loss Ratio. The friction loss ratio of microfin tube was approximately unity due to which pressure drop in microfin tube was almost same as that of plain tube. A small increase in heat transfer and pressure drop coefficients was obtained by using microfin tubes over the plain tubes therefore, the studied microfin tubes were not found useful for laminar flow.

Liao et. al. [12] carried out an investigation on tubes with three dimensional internal extended surfaces. Experiments were performed to investigate heat transfer and friction characteristics for ethylene glycol, water, and ISO VG46 turbine oil with laminar, transitional and turbulent flow through four tubes with three dimensional internal extended surfaces and copper continuous or segmented twisted tape inserts. On three copper, continuous twisted tapes insert the experiments were conducted with twist ratio 5, 10 and15 along with two copper segmented twisted tape inserts with a twist ratio of 10 and 15. The range of Prandtl number (Pr) and Reynolds number (Re) was 5.5–590 and 80–50,000 respectively. The results showed that by using 3 DIEST tubes technique with twisted tape inserts to increase heat transfer rate is suitable for laminar flow of highly viscous fluid flowing through tube. Also, there was found a small increase in heat transfer for transitional and turbulent flow but friction factor increases considerably.

C. Thianpong et. al [13] conducted an experimental investigation for heat transfer and pressure drop analysis for turbulent flow with perforated twisted tapes in heat exchanger. The experimentation is carried out for perforated twisted tapes of having hole diameter ration d/W is 0.11, 0.33 and 0.55 with wing depth ratio w/W is 0.11. 0.22 and 0.33. Experimental result shows that the heat transfer enhancement in perforated twisted tube and twisted tube is be up to 208% and 190% as compared to plain tubes. Perforated twisted tube with same pumping power having d/W ratio 0.11 and 0.33 gave the maximum thermal performance factor of 1.33 at Reynolds number of 5500. The empirical relations for friction factor, heat transfer and thermal performance for perforated twisted tube were also developed.

Bodius Salam et. al. [14] carried out experiments for measuring tube side heat transfer, friction factor, heat transfer enhancement using twisted tapes with rectangular cut. A stainless-steel tape with rectangular cut with twist ratio 5.25 is used as insert in tube heat exchanger. The rectangular cut had 8 mm depth and 14 mm width. The experimentation is carried out for uniform heat flux which is maintained with the help of nichrome wire. The heat flux variation 14 to 22 kW/m2 for smooth tube, and 23 to 40 kW/m2 for tube with insert with varring Reynolds numbers between 10000-

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19000. Nusselt numbers obtained from smooth tube were compared with Gnielinski correlation and errors were found to be in the range of -6% to -25% with r.m.s. value of 20%. Nusselt numbers in tube with rectangular-cut twisted tape insert were enhanced by 2.3 to 2.9 times at the cost of increase of friction factors by 1.4 to 1.8 times compared to that of smooth tube as compared to Reynolds number. Heat transfer enhancement efficiencies were found to be in the range of 1.9 to 2.3 and increased with the increase of Reynolds number.

Sombat Tamna et. al. [15] conducted an experimental work on heat transfer enhancement in a round tube by insertion of 300 V-shaped ribs on twisted tapes. The working fluid is air in test tube having a constant wall heat-flux with Reynolds number varies between 5300 to 24000. Thermal characteristics of V-ribs parameter such as relative rib height having dimensions BR= b/D= 0.07, 0.09, 0.14 and 0.19 along with relative rib pitch PR=P/D=1.9. at 300 attack angle is investigated. The experimental results shows that pressure drop and heat transfer enhancement in terms of friction factor and Nusselt number in V-ribbed twisted tapes increases as increase in Reynolds number and Blockage ratio (BR). the highest heat transfer and friction factor occurs for BR=0.19, but the maximum thermal enhancement is about 1.4 for the V-ribbed twisted tape having BR=0.09 as compared to no rib tapes which having thermal enhancement 1.09.

K. Nanan [16] studied the impact of perforated helical twisted-tapes (P-HTTs) on the thermal performance characteristics, friction loss and heat transfer under a uniform heat flux condition is reported. The P-HTTs were obtained by punching typical helical twisted-tapes (HTTs) with a prospect to reduce the friction loss of fluid flow. The P-HTTs' having three different diameter ratios (d/w) of 0.2, 0.4 and 0.6 were used for experiments, along with three different perforation pitch ratios (s/w) of 1, 1.5 and 2. The ratio of helical pitch and twist were fixed at P/D = 2 and y/w = 3. The experiment is carried out for Reynolds number ranging between 6000 and 20,000. The experiments for comparison is carried out using the plain tube and the tubes with HTTs for assessment. The experimental results shows that the use of P-HTTs leads to the decreases the friction loss as compare to that of HTT. Heat transfer, friction loss and thermal performance factor increase as d/w decreases and s/w increases. The maximum thermal performance factor of 1.28 is obtained by using the P-HTT with d/w = 0.2 and s/w = 2.0 at the Reynolds number of 6000. The empirical correlations for thermal performance factor, friction factor and Nusselt number give accurate predictions within ±3%, ±6% and ±4%, respectively.

Bhuiya M. M. K [17] presented the study which explored the effect of perforated double countered twist tape on heat transfer and friction characteristics in heat exchanger. The twisted tapes with different percentage of porosities RP= 1.2, 4.6, 10.4 and 18.4 were used as a contour flow generation. The experimentation is conducted for Reynolds number ranging from 7200 to 50000 in turbulent flow region using air as working fluid at constant wall heat flux. The experimental result shows that the friction factor, thermal enhancement efficiency and Nusselt number is increases with decreasing porosities except at 1.2%. the result is also shows that the heat transfer rate of tube with twisted tapes is increases with increase in friction factor. In the range of the present study, friction factor and heat transfer rate were obtained to be around 111 to 335% and 80 to 290% more than those of the plain tube values, respectively. The highest thermal enhancement efficiency of 1.44 was achieved for constant blower power. In addition, the empirical correlations of Nusselt number, friction factor and thermal enhancement efficiency were developed based on the experimental data.

III. EXPERIMENTATION

A. Experimental Setup:

A schematic drawing of the facility used for heat transfer measurements is shown in Fig. The average heat transfer coefficient on the circular tube was measured for various rates of hot and cold-water flow through the inner tube and outer tube. It consists of an open loop flow circuit having two centrifugal pump units fitted with a circular tube, which is connected to the test tube located in horizontal orientation. The test tube which is of copper material, 26 mm ID, 1 mm thickness and 1.5 m length is used for experimentation.

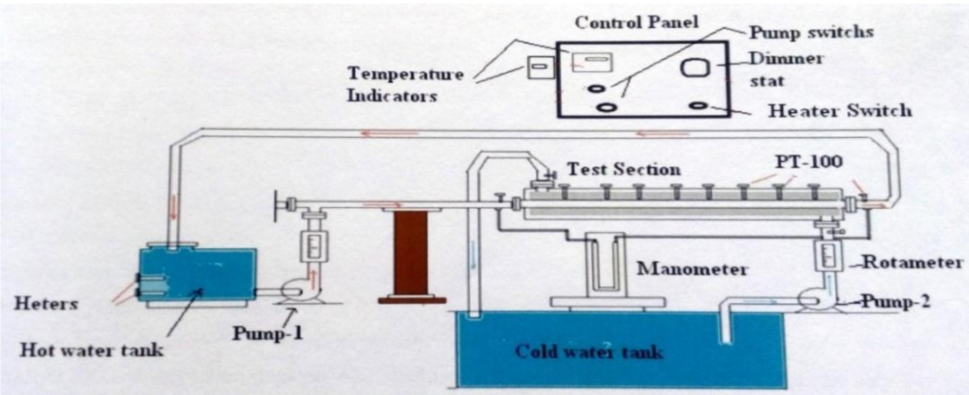

Figure 1 Schematic diagram of experimental Setup

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Four thermo-couples at the inlet and outlet of cold and hot water flow are embedded. The measurement of surface temperature across the fluid flow five thermocouple is attached at equal distance. The digital device temperature indicator is used to display the temperature measured by thermocouple at various position.

Figure 2: Experimental Setup

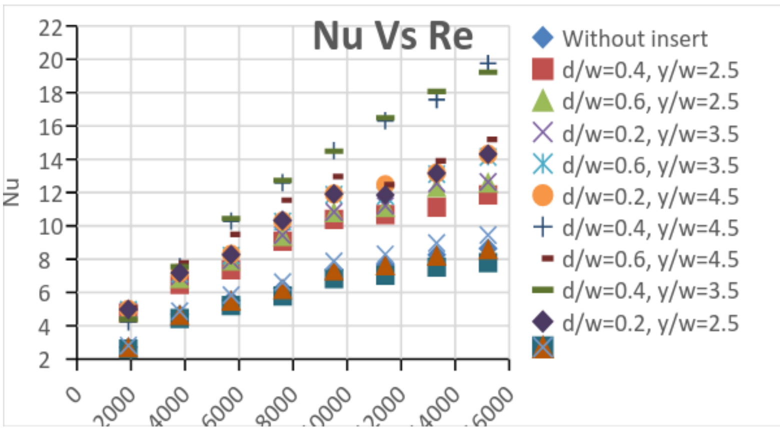
A U tube manometer is used to measure the pressure drop across the test section. Typically, the pipe system consists of a valve, which controls the water flow rate through it and two rotameters to find the volume flow rate of water through the system. The two pressure tapings of the test section are connected to a U-tube manometer to indicate the pressure difference between them. The insulation is provided to reduce the heat flow through the surface to atmosphere air. The PUF insulation is used to avoid the heat transfer to the atmospheric air. The thickness of insulation is 8 mm.

IV. RESULT AND DISCUSSION

The experimental procedure and sample calculation is discussed in previous chapter. This chapter deals with the obtained results and its interpretation. The effect of Reynolds number on Nusselt's number, pressure drop, and performance evaluation criteria R1 is studied. This parameter is studied for without insert and also insert with and without perforation for different d/w and y/w ratio. Then comparative studied is carried out and summarized in this chapter.

A. Nusselt's Number

The Graph 1 shows the variation of Nusselt's number on Reynold's number for plain tube and the tube equipped with P-HTT inserts. As the Reynold's number is increased the value for Nusselt's number is also increasing. The values of Nusselt's number is low for plain tube and insert without perforation, as compared to the Nusselt's number of inserts having perforation. At a given Reynolds number, the use of twisted tape inserts leads to considerable increase of Nusselt number as compared to that of the plain tube. This can be explained that the thermal boundary becomes thicker as Reynolds number decreases, thus the effect of boundary destruction by inserts turns out to be more prominent.



Graph 1 Effect of Nusselt's number over Reynold's Number

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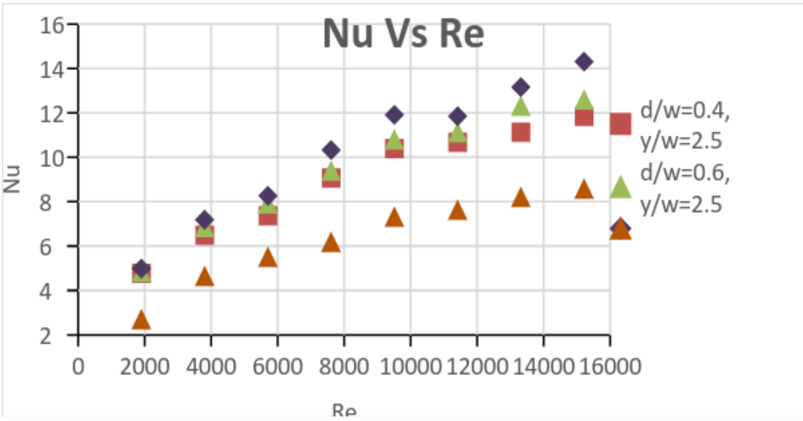
The Nusselt numbers for the tubes with tape inserts are enhanced between 72.8% and 112.7%, over that for the plain tube. This is primarily attributed to the effect swirl flow induced by the tape inserts which leads to stronger turbulent intensity and tangential contact between the fluid flow and tube wall.

a. Effect of pitch ratio (y/w):

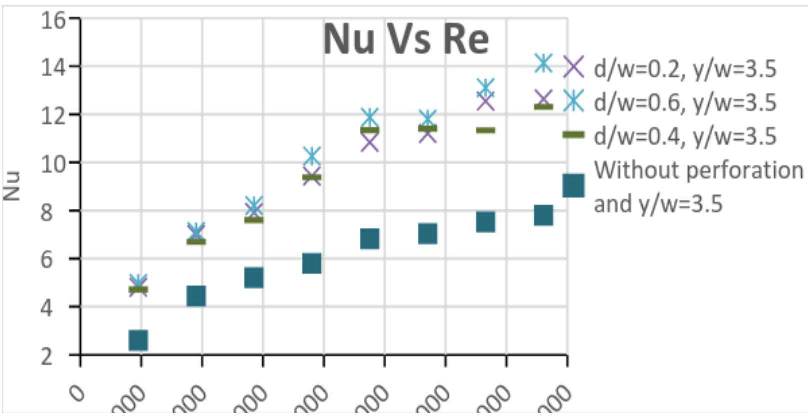
The Graph 2 to Graph 4 shows the effect of Nusselt's number on Reynold's number for their pitch ratio 2.5, 3.5 and 4.5 respectively. This variation is plotted for various perforation ratio d/w for same pitch ratio. The d/w ratio for this study is 0.2, 0.4 and 0.6. The Graph 2 is shows that the Nusselt number for PTT is more than the normal TT. The Nusselt number will be more for lower d/w i.e. 0.2.

At the given Reynolds number, the Nusselt number is consistently increasing with decrease in d/w. This is occurring due to the smaller perforation create stronger turbulence in fluid. Also, it gives longer flowing path which leads to longer residence time and thus more effectively heat transfer takes place.



Graph 2 Effect of Nusselt's number over Reynold's number for y/w=2.5

Graph 3 shows the effect of Nusselt number with respect to the Reynolds number for pitch ratio y/w=3.5. the nature of graph is slightly different than the Graph 2. Here the Nusselt number for d/w=0.4 is more as compared to the d/w=0.2. This is occurred due to the change in pitch ratio y/w from 2.5 to 3.5. the increased value of y/w produces vortex of fluid. It disturbs the film of fluid nearer to the surface of tube and contribute to the more heat transfer.



Graph 3 Effect of Nusselt's number over Reynold's number for y/w=3.5

Considering the effect of twist ratio on Nusselt number it is found that with increase in y/w up to certain condition along with d/w the values is going to increase and letter on it will get decrease. This is because of the turbulence intensity generated in fluid.

B. Performance evaluation criteria R1:

The various criteria are available to evaluate the performance of the heat transfer enhancement device. Bergles [18] have also suggested several criteria for the evaluation of performance. The performance of the heat transfer enhancement device is evaluated on the basis of constant mass flow rate.

R1= (hptt)/(hwtt) , Where, hptt – Heat transfer coefficient for perforated twisted tape

hwtt – Heat transfer coefficient for without twisted tape

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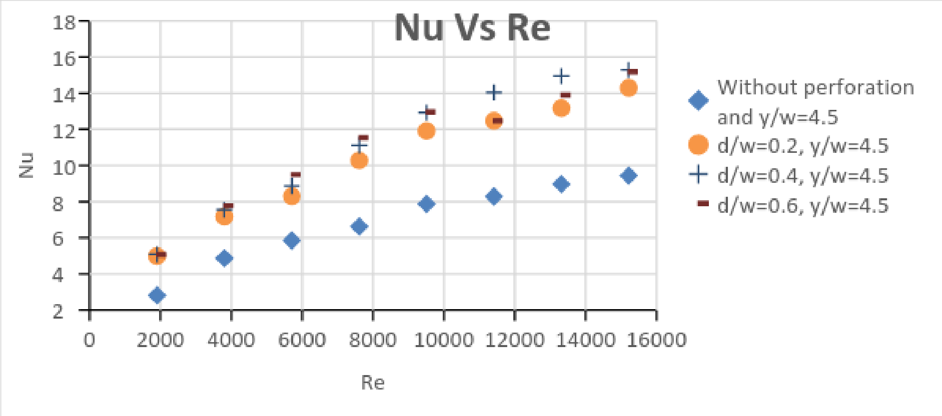
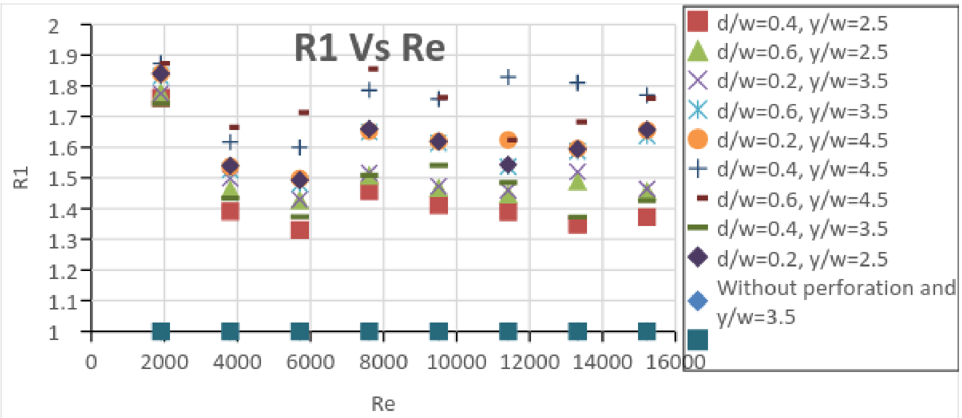


Graph 4 Effect of Nusselt's number over Reynold's number for y/w=4.5

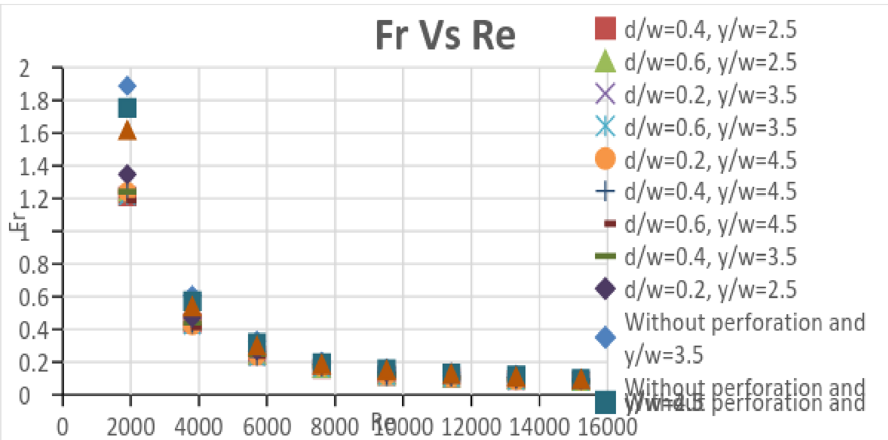


Graph 5 Performance Evaluation Criteria (R1) Vs Reynolds number for all cases

In Graph 5 the effect of performance evaluation criteria (R1) over the different values of Reynolds number is shown for all type of perforated twisted tapes. The maximum performance is shown by the d/w=0.4 and y/w=4.5. from this result, we can say that this will be the best arrangement out of all tested arrangement in these experimentations.

The results indicate that the PTT with moderate perforation performance factor increases as perforation diameter ratio (d/w) decreases and perforation pitch ratio (s/w) increases. The PTTs with s/w = 4.5 enhance thermal performance factor around 4.5% to 5.4% and 0.4% to 1.1% over those given by the PTTs with s/w = 3.5 and 2.5, respectively. The maximum thermal performance factor of 1.86 is obtained by using the PTT with the perforation diameter (d/w = 0.4) and the largest perforation pitch (s/w = 4.5) at the lowest Reynolds number of 3800.

C. Friction Factor



Graph 6 Friction factor Vs Reynolds number for all studied arrangement

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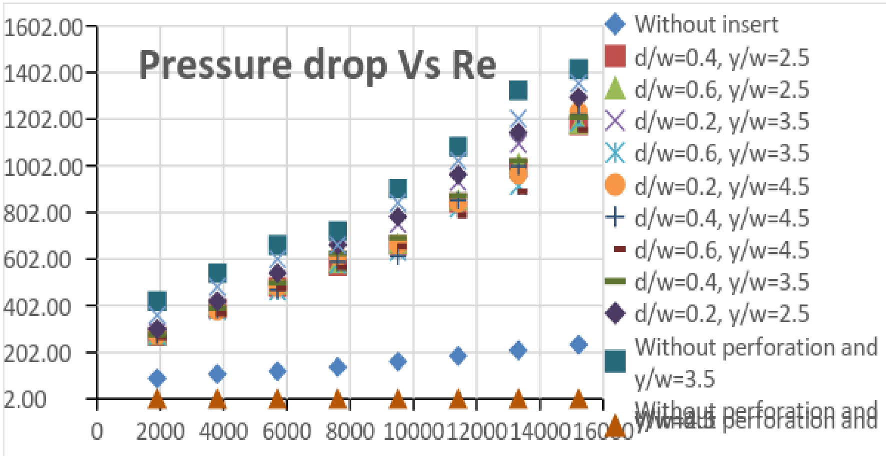
In design of Heat exchanger, pressure drop is one of the important parameter as it decides the pumping power require to circulate fluid through the exchanger. The good heat exchanger should have high thermo hydraulic efficiency. It means the device has to provide larger surface area for heat transfer and lower pumping power. Hence it is essential to study the effect of different inserts on the pressure drop. It is comparatively studied by calculating the friction factor for all arrangements.

The results of Friction factor (FR) with respected to Reynolds number is shown in Graph 6 for various pitch ratio and perforation ratio (i.e. y/w= 2.5, 3.5& 4.5 and d/w=0.2, 0.4 and 0.6). The friction factor value will get decrease with respect to the increase in Reynolds number. The results show that the value for friction factor will get increase by decreasing the d/w ratio. Because twisted tape with shorter twist length provides longer flowing path, resulting in larger tangential contact between the flowing stream and tube surface. Therefore, loss due to the friction increases. The larger pressure drop is not desirable. Hence to select the proper insert for heat transfer enhancement, one has to determine the enhancement efficiency which is ratio of Nusselt's number to Friction factor.

The maximum friction factor is obtained at low Reynolds number, this is because the more force is required to overcome the resistance offered by the twisted tape and also the inertia of fluid is very low. As the perforation diameter increased the friction factor is decreased. Also, it gives the decrease in friction factor with increasing the y/w ratio. The minimum friction factor is obtained for y/w=4.5 and d/w=0.6 as this offered less resistance to flow.

D. Pressure Drop

The effect of pressure drop for different arrangement of inserts with Reynolds number is shown in Graph 7. As we use inserts into the tube, it offered the resistance to the fluid motion. Hence the pressure into the system is decreased. For efficient system pressure drop required is minimum but because of resistance by inserts in this study the pressure will get decreased.



Graph 7 Effect of Pressure Drop over the Reynold's Number for different arrangement

The Graph 7 shows the effect of pressure drop with respect to the Reynolds number. As Reynolds number increases the pressure drop is increase because of more turbulence is created and hence pressure drop is occurred. The plain tube having minimum pressure drop as shown in graph. The twisted tube without perforation is offer maximum resistance hence pressure drop is more in this study. The minimum pressure drop is obtained into the PTT having d/w=0.6 and y/w=4.5. The more amount of fluid can pass through the perforation and also the pitch size is more hence less resistance can be offered by this type of arrangement. As the pitch size is increase and d/w ratio increases less pressure drop can be obtained.

E. Heat Transfer Coefficient

Graph 8 shows the effect of heat transfer coefficient over the pressure drop for all type of arrangement. The system required high heat transfer coefficient and low pressure drop. But in actual practice as the heat transfer coefficient increase by using a twisted tape it also decreases the pressure of system as TT increases the resistance to fluid motion.

The pressure drop is more for twisted tapes without perforation as compared to the twisted tape with perforation. The heat transfer coefficient is more for PTT. The best arrangement by considering the pressure drop and heat transfer coefficient is d/w=0.6 and y/w=4.5. It is having more heat transfer coefficient and less pressure drop as compared to other PTT and twisted tape without perforation.

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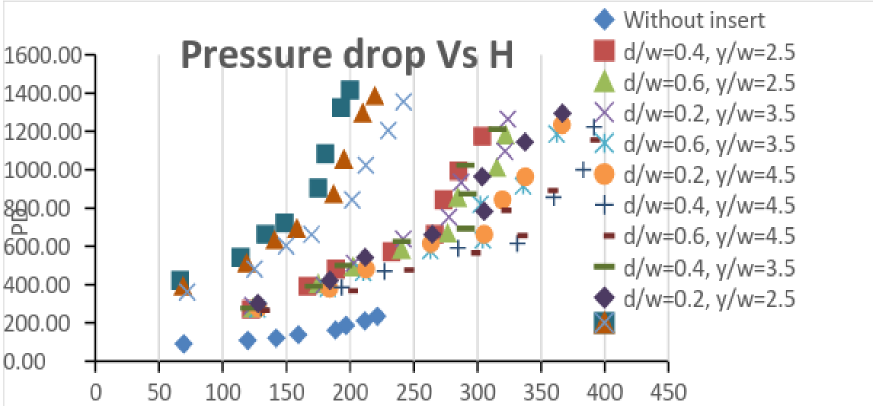

Graph 8 Pressure Drop Vs Heat Transfer Coefficient

V. CONCLUSION

Augmentation of heat transfer rate in heat exchanger tubes by means of perforated twisted tapes (PTT) inserts is investigated experimentally. The results showed those heat transfer and friction factors were significantly influenced by the presences of holes on PTTs. Both heat transfer and friction increased with the increase of depth ratio (y/W) and the decrease of perforation hole diameter ratio (d/W). Due to the dominant effect of increased heat transfer over that of increased friction factor, the thermal performance factor was found to be increased as depth ratio (w/W) increased and hole diameter ratio (d/W) decreased.

REFERENCES

[1] P. Eiamsa-ard, N. Piriyarungroj and C. Thianp, "P. Eiamsa-ard, et al. N. PiriyaA case study on thermal performance assessment of a heat exchanger tube equipped with regularly-spaced twisted tapes as swirl generators," Elsevier Case Studies In Thermal Engineering,, 2014.
[2] S. Naga Sarada, A.V. Sita Rama Raju, K. Kalyani Radha, L. Shyam Sunder, "Enhancement of heat transfer using varying width twisted tape inserts," International Journal of Engineering, Science and Technology, vol. 2, pp. 107-118, 2010.
[3] A.Rahul kumar, P.N.S Srinivas, "Experimental Analysis of Heat Transfer Augmentation by Using Twisted Tapes of Different Twist Ratio as Flow Arrangement inside the Tubes," International Journal of Modern Engineering Research, vol. 3, no. Department of mechanical engineering, Sri Vasavi institute of engineering & technology, Jntuk, India, pp. 1317-1323, June 2013.
[4] W.H.Azmi, K.V.Sharma, Rizalman Mamat, and Shahrani Anuar, "Turbulent forced convection heat transfer of nanofluids with twisted tape insert in a plain tube," in ScienceDirect, Malaysia, 2014.
[5] Mr. A.V.Gawandare, Prof. M.M.Dange, Prof.D.B.Nalawade, "Heat Transfers Enhancement with Different Square Jagged Twisted Tapes," International Journal of Engineering Research and Applications, vol. 4, pp. 619-624, March 2014.
[6] A. E. Zohir, "Turbulent heat transfer characteristics and pressure drop in swirling flow at upstream and downstream of an abrupt expansion," Springer-Verlag, vol. 48, pp. 529-539, 2012.
[7] S. Eiamsa-ard, K. Kiatkittipong, W. Jedsadaratanachai, "Heat transfer enhancement of TiO2/water nanofluid in a heat exchanger tube equipped with overlapped dual twisted-tapes," Elsevier, no. Department of Mechanical Engineering, Faculty of Engineering, Mahanakorn University of Technology, Bangkok 10530, Thailand, pp. 1-15, January 2015.
[8] Yu. A. Kuzma-Kichta, P. A. Savel'ev, S. A. Koryakin, and A. K. Dobrovol'skii, "Studying of Heat-Transfer Enhancement in Tubes with Screw Knurling," Thermal Engineering, vol. 54, pp. 407-409, 2007.
[9] R. R. M. Aggarwal SK, "Heat Transfer Augmentation for the flow of a viscous liquid in circular tubes using twisted tape inserts," Int J Heat Mass Transf , pp. 3547-3557, 1996.
[10] C. W. Al-Fahed Sami, "Effect of tube-tape clearance on heat transfer for fully developed turbulent flow in a horizontal isothermal tube," Int J Heat Fluid Flow, pp. 173-178, 1996.
[11] C. L. C. W. Al-Fahed S, "Pressure drop and heat transfer comparison for both micro fin tube and twisted tape inserts in laminar flow.," Exp Therm Fluid Sci, pp. 323-333, 1999.
[12] X. M. Liao Q, "Augmentation of convective heat transfer insides tubes with three dimensional internal extended surfaces and twisted tape inserts," Chem Eng J, pp. 95-105, 2000.
[13] P. E.-a. P. P. S. E.-a. C. Thianpong, "Effect of perforated twisted-tapes with parallel wings on heat transfer enhancement in a heat exchanger tube," 2nd International Conference on Advances in Energy Engineering (ICAEE), pp. 1117-1123, 2011.
[14] S. B. S. S. M. M. K. B. Bodius Salam, "Heat transfer enhancement in a tube using rectangular-cut twisted tape insert," 5th BSME International Conference on Thermal Engineering, pp. 93-103, 2013.
[15] Y. K. S. S. b. Sombat Tamna, "Heat transfer enhancement in tubular heat exchanger with dubble V-ribed twisted tapes," Case StudiesinThermalEngineering, pp. 14-24, 2016.
[16] C. T. P. P. S. E.-a. K. Nanan, "Investigation of heat transfer enhancement by perforated helical twisted tapes," International Communications in Heat and Mass Transfer, pp. 106-112, 2014.
[17] A. A. M. C. M. S. M.M.K. Bhuiya, "Heat transfer augmentation in a circular tube with perforated double counter twisted tape inserts," International Communications in Heat and Mass Transfer, 2016.
[18] A. B. A. Bergles, "Performance evaluation criteria for enhanced heat transfer surfaces," 5th International Heat Conference, Tokyo, vol. 2, pp. 239-243, 1974.