Asian Journal of Applied Science and Technology (AJAST)
(Peer Reviewed Quarterly International Journal) Volume 3, Issue 3, Pages 151-159, July-September 2019

Review of Heat Transfer Enhancement in Shell and Tube Heat Exchanger with Twisted Tape

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Article Received: 29 January 2019 Article Accepted: 23 May 2019 Article Published: 13 August 2019

ABSTRACT

The main objective of this paper is to find the heat transfer rate of a shell & tube heat exchanger by using of twisted tapes in the tubes of the heat exchanger. The swirl flow behavior is occurring by twisted tape use that increases the heat transfer coefficient considerably. The KERN method is used in a circular tube with twisted tape. The fluid flow and thermal fields are simulated computationally in an effort to characterize their structure. For long term performance & detailed the economic analysis and the other parameter of heat exchanger is studied to achieve high heat transfer rate in a heat exchanger while taking care of the increased pumping power. It was found that the heat transfer coefficient and the pressure drop in the tubes with the longitudinal twisted tape inserts were 7–16% and 100–170% greater than those of plain tubes without inserts. When the longitudinal strip inserts with holes were used, the heat transfer coefficient and the pressure drop were 13–28% and 140–220%, respectively, higher than those of plain tubes. The heat transfer coefficient and the pressure drop of the tubes with twisted- tape inserts were 13–61% and 150–370%, respectively, higher than those of plain tubes. Furthermore, it was found that the reduction ratio in the heat transfer area of the tube of approximately 18–28% may be obtained if the twisted-tape tube inserts are used.

Keywords: Twisted tapes, Kern Method, Reduction ratio, Shell and Tube Heat exchanger.

1. INTRODUCTION

The heat exchanger that exchange the heat between the two fluids by the temperature difference. It exchange the hot to cold and cold to hot fluids. The heat transfer rate is depend on the magnitude of temperature difference , and a variety of heat exchangers are used in different type of installations, as in process industries, compact heat exchangers nuclear power plant, HVACs, food processing, refrigeration, etc. The purpose of constructing a heat exchanger is to get an efficient method of heat transfer from one fluid to another, by direct contact or by indirect contact. The heat transfer occurs by three principles: conduction, convection and radiation. In a heat exchanger the heat transfer through radiation is not taken into account as it is negligible in comparison to conduction and convection. the main components of shell &tube Heat exchanger is Water level indicator, Pressure relief valve, Pressure gauge Heater, Tube, Water outlet, Rotameter, pump, Water pump, and Shell.

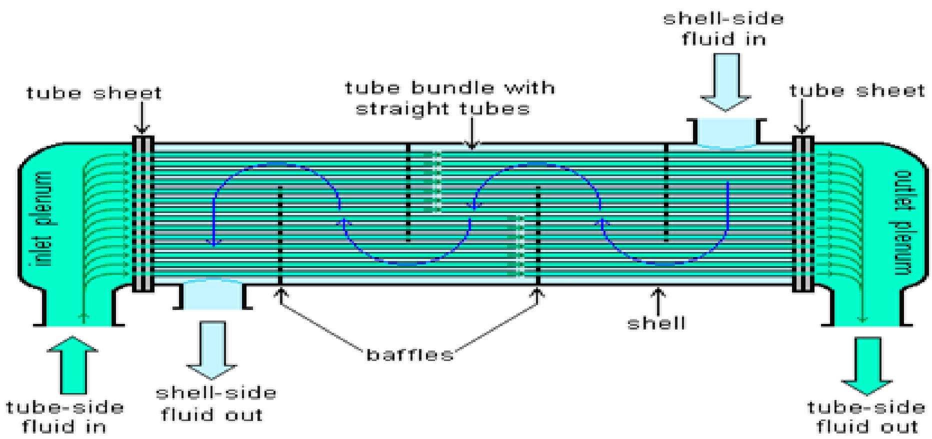


Fig.1.1 Shell and tube heat exchanger

Plate heat exchangers

Another type of heat exchanger is the plate heat exchanger. These exchangers are made out of some thin, somewhat isolated plates that have expansive surface zones and little liquid stream entries for heat exchange. Advances in gasket and brazing innovation have made the plate-type heat exchanger progressively down to earth. In HVAC applications, extensive heat exchangers of this type are called plate-and-casing; when utilized as a part of open circles, these heat exchangers are ordinarily of the gasket type to permit occasional disassembly, cleaning, and investigation.

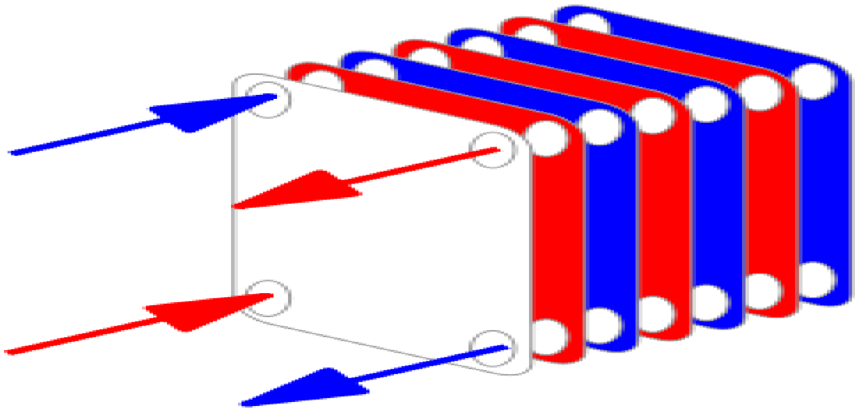


Fig.1.2 Plate heat exchangers

Plate and shell heat exchanger

A third type of heat exchanger is a plate and shell heat exchanger, which combines plate heat exchanger with shell and tube heat exchanger advances. The heart of the heat exchanger contains a completely welded roundabout plate pack made by squeezing and cutting round plates and welding them together.

Adiabatic wheel heat exchanger

A fourth sort of heat exchanger utilizes a halfway liquid or strong store to hold heat, which is then moved to the opposite side of the heat exchanger to be discharged. Two cases of this are adiabatic wheels, which comprise of an extensive wheel with fine strings pivoting through the hot and cool liquids, and liquid heat exchangers.

Plate fin heat exchanger

This kind of heat exchanger utilizes "sandwiched" sections containing balances to expand the effectiveness of the unit. The outlines incorporate cross flow and counter flow combined with different fins setups, for example, straight balances, balance balances and wavy balances. Plate and fin heat exchangers are generally made of aluminum alloys, which give high heat exchange productivity. The material empowers the framework to work at a lower temperature difference and decrease the heaviness of the hardware. Plate and fin heat exchangers are for the most part utilized for low temperature administrations, for example, gaseous petrol, helium and oxygen liquefaction plants, air partition plants and transport ventures, for example, engine and flying machine motors.

2. MECHANISM OF HEAT TRANSFER

Twisted tapes have been generally applied as heat transfer enhancing devices in heat exchanger. In this part the main and effective mechanisms of heat transfer enhancement are analysed for better understanding of twisted tape property. The fluid in tube with twisted tape in Fig. 3 presents the helical flow, the cutting speed and the radial velocity of flow near the wall have been improved compared to the plain tube. The centrifugal force induced by tangential velocity accelerates the mixing between the main stream zone and the near wall zone [18].

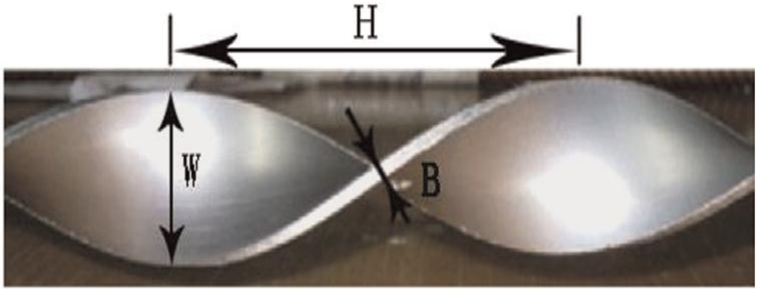


Fig. Structure sketch map of twisted tape.

The main mechanisms of heat transfer enhancement due to twisted tape include:

(1) The reduction of a hydraulic diameter of heat transfer tube causes an increase of flow velocity and curvature, which in turn can increase the shear stress near the wall and drives secondary motion.

(2) The velocity increase near the tube wall due to the blockage of the twisted tape which reduces thickness of the boundary layer.

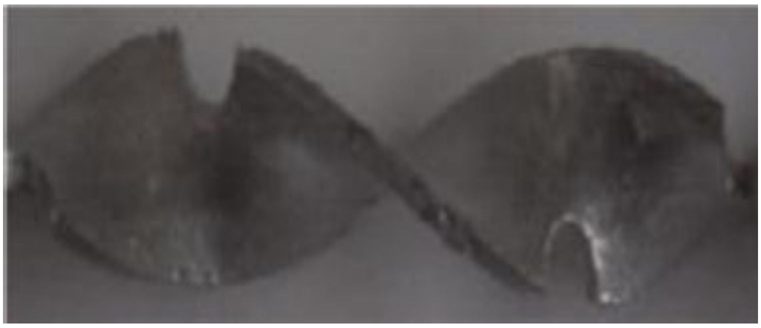
(3) The velocity increase due to the helical flow following the twisted tape.

(4) The induced swirling flow makes a better fluid mixing between the core and the near-wall flow regions.

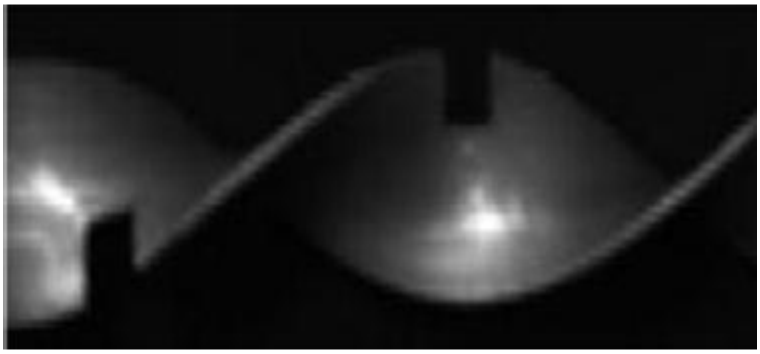
Typical twisted tape

Perforated twisted tape

Notched twisted tape

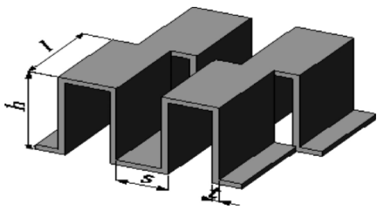


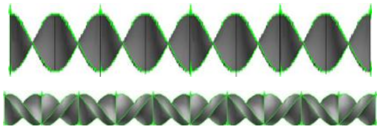
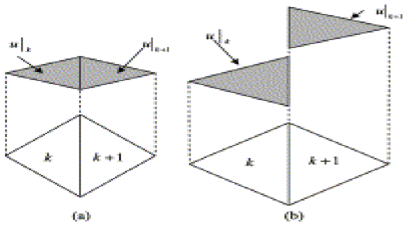
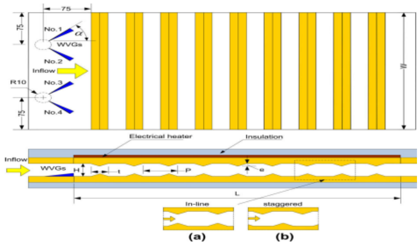
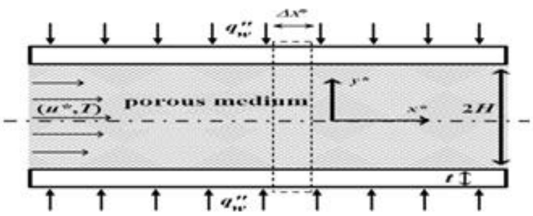
Square-cut twisted tape

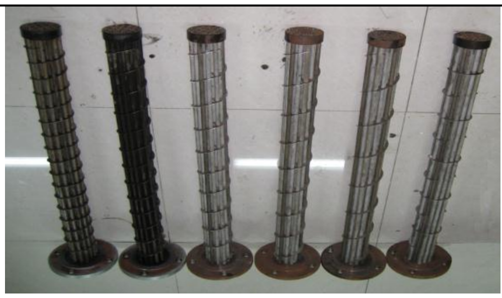
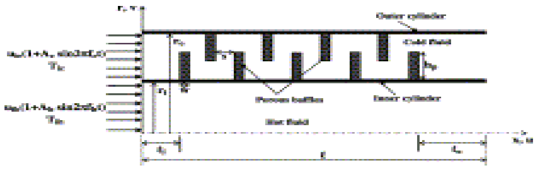
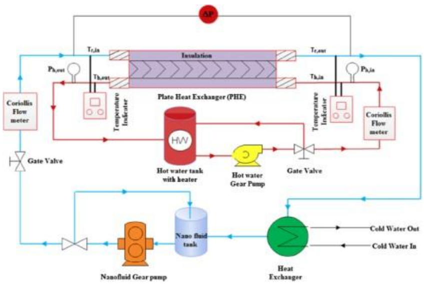
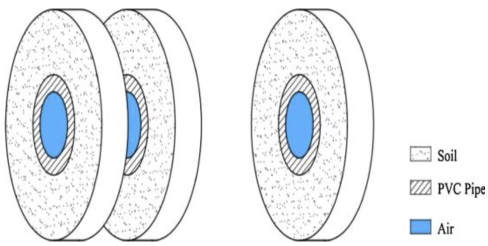


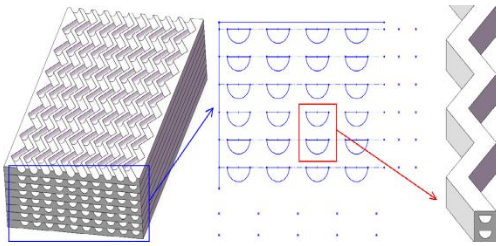
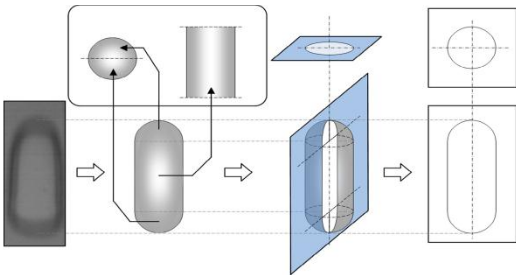
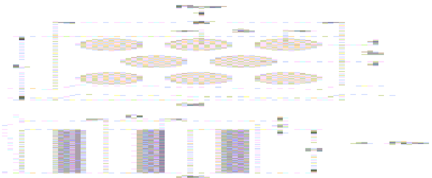
Double twisted tape

TABLE 1: DIFFERENT GEOMETRY OF DIFFERENT AUTHORS

S.NO	Author	Geometry	Conclusion
1.	Jian Wen, Huizhu Yang, et al.[2016]	Plate-fin heat exchangers with serrated fin  **Fig.2.1**	The total heat flow rate, the total annual cost and the number of entropy production units of PFHEs are optimized with the specified mass flow rate under given space.

2.	JaisankarS,et al.[2011]	Thermosyphon solar water heating system with helical and Left- Right twisted tapes  **Fig. 2.2**	The results show that heat transfer enhancement in twisted tape collector is higher than the plain tube collector. Compared to helical and Left–Right twisted tape system of same twist ratio 3, maximum thermal performance is obtained for Left–Right twisted tape collector with increase in solar intensity.
3.	SyedKS, MuhammadIshaq, Iqbal et al.[2015]	Finned double-pipe heat exchanger with variable fin-tip thickness  **Fig. 2.3**	The results indicate that the newly introduced parameter the ratio of tip to base angles has proved to play significant role in the design of a double-pipe heat exchanger in reducing the cost, weight and frictional loss, in improving the heat transfer rate and making the exchanger energy-efficient.
4.	Promvonge Pongjet, Thianpong et al,[2010]	Triangular ribbed channel with longitudinal vortex generator  **Fig.2.4**	The experimental results show a significant effect of the presence of the rib turbulator and the WVGs on the heat transfer rate and friction loss over the smooth wall channel. The values of Nusselt number and friction factor for utilizing both the rib and the WVGs are found to be considerably higher than those for using the rib or the WVGs alone.
5.	DehghanMaziar, Valipour et al.[2016]	Microchannels enhanced by porousmaterials  **Fig.2.5**	Results reveal that the HTP may effectively be increased by inserting rarefied porous inserts. The present analysis suggests the implementation of porous inserts within flow passages especially when 0.001 < Kn < 0.1 (the slip- flow regime).
6.	Chen Ya-Ping, Wang et al,[2015]	Helical baffled heat exchangers	The results show that both the shell side heat transfer coefficient ho and pressure drop po increase but the comprehensive index ho/po decreases with the increase of the mass flow rate of all scheme;

		 **Fig.2.6**	
7.	PromvongeP, Eiamsa-ard S.[2006]	Conical-nozzle inserts and swirl generator  **Fig.2.7**	The heat transfer in the circular tube could be enhanced considerably by fitting it with conical-nozzle inserts and snail entrance. Although they provide higher energy loss of the fluid flow; the loss is low especially at low Reynolds number.
8.	Targui N, Kahalerras H.[2013]	double pipe heat exchanger performance by use of porous baffles and pulsating flow  **Fig.2.8**	The results reveal that the addition of a oscillating component to mean flow affects the flow structure and enhances the heat transfer in comparison to the steady non pulsating flow.
9.	Kumar Vikas, Tiwari et al.[2016]	Plate heat exchanger using ZnO/water Nanofluid  **Fig.2.9**	Experimental observation confirm that optimum enhancement in heat transfer rate ratio, heat transfer coefficient ratio and optimum reduction in exergy loss are obtained at β=60/60 for 1.0% particle volume concentration of ZnO/water nanofluid.
10.	Barakat S, Ramzy Ahmed, et al.[2016]	gas turbine power output using earth to air heat exchanger (EAHE) cooling system  **Fig.2.10**	The output power and thermal efficiency of gas turbine increases by 9% and 4.8%; respectively. In addition the annual revenue will increase by 1.655*106 $ with payback period of 1.2 year.

11.	Ma Ting, Li Lei, Xu Xiang et al.[2015]	zigzag-type printed circuit heat exchanger  **Fig.2.11**	Therefore the local Nusselt number and friction factor at high temperature can match well with those at low temperature when the Reynolds number is bigger than 900. With the increase of inclined angle, the heat transfer and pressure drop increase.
12.	Masiukiewicz Maciej,Anweiler Stanisław.[2015]	Two-phase flow phenomena assessment in minichannels for compact heat exchangers  **Fig.2.12**	The major result of conducted research is that for each flow structure there is a set of stereological parameters, enabling the quantitative estimation of the two-phase flow.
13.	Shi Zhongyuan, Dong Tao.[2015]	Microchannel with staggered arrays of pin fin  **Fig.2.13**	Within the scope of the present work, entropy generation rate due to heat transfer is levels of magnitude higher than that from flow friction.

3. CONCLUSION

This paper provides an overview of self-rotating and stationary twisted tapes. The thermal characteristic, anti-fouling and descaling Performances of self-rotating twisted tapes compared to stationary twisted tapes have been comprehensively discussed. The influences of structure parameters on the performance have been comparatively analysed.

The conclusions of this paper are listed as follows:

1. Compared with the stationary twisted tapes, the heat transfer enhancement and the function of online anti-scaling and descaling can be obtained with the self-rotating inserts in tube. Meanwhile, the tube with self-rotating twisted tapes gives the Lower pressure drop in there searches.

2. The twisted tapes achieve remarkable and effective characterizes in laminar regions than in turbulent regions. Meanwhile, the twisted tape shave significant performance both in common fluid and nano fluid.

3. The Nusselt number and friction factor in the tube with cut twisted tape increase with decreasing twist ratios, width ratios and increasing depth ratios. The heat transfer and friction factor increases with decreasing the twist ratio and the width of twisted tape. The performance factors of all twisted tapes tend to decrease with increasing Reynolds number.

4. The novel twisted tapes can achieve an optimal comprehensive Performance compared with the typical twisted tape, for the Former can offer a stronger swirl flow to provide superior mixing And more efficient interruption of thermal boundary layer or Have the access to prevent the formation of higher pressure drop.

5. The major criterion for selecting superior twisted tape configurations is the high value of thermal performance factor. All of these selected modified scheme shave better thermal performance factor than typical twisted tape. The values of self-rotating twisted tape are higher than stationary twisted tapes.

6. The twisted tape, which is relevant to minimum pressure drop conjugate with the maximum heat transfer rate, is the optimal shape. At the same time, the method of twisted tape combined with other techniques is the new development direction of heat transfer enhancement.

REFERENCES

[1] Zhang C, Li Y, Wang L, Xu K, Wu J. Review heat exchanger: research development of self- rotating inserts in heat exchanger tubes. Int J Eng Trans A: Basics 2014;27:1503–10.

[2] Zhang C, Wang D, Zhu Y, Han Y, Wu J, Peng X. Numerical study on heat transfer and flow characteristics of a tube fitted with double spiral spring. Int J Therm Sci2015;94:18–27.

[3] Saha S, Saha SK. Enhancement of heat transfer of laminar flow through a circular tube having integral helical rib roughness and fitted with wavy strip inserts. ExpThermFluidSci2013;50:107–13.

[4] Anvari AR, Lotfi R, Rashidi AM, Sattari S. Experimental research on heat transfer of water in tubes with conical ring inserts in transient regime. Int Commun HeatMass2011;38:668–71.

[5] Anvari AR, Javaherdeh K, Emami- Meibodi M, Rashidi AM. Numerical and experimental investigation of heat transfer behaviour in a round tube with the special conical ring inserts. Energy Convers Manag 2014;88:214–7.

[6] Zhang Z, Yang W, Guan C, Ding Y, LiF, Yan H. Heat transfer and friction characteristics of turbulent flow through plain tube inserted with rotor- assembled strands.ExpThermFluidSci2012;38:33–9.

[7] Liu S, Sakr M. A comprehensive review on passive heat transfer enhancements in pipe exchangers. Renew Sustain Energy Rev2013;19:64–81.

[8] Hasanpo ur A, Farhadi M, Sedighi K. A review study on twisted tape inserts on turbulent flow heat exchangers: the overall enhancement ratio criteria. Int Commun Heat Mass2014;55:53–62.

[9] Lin Q, Lin J, Lin R. Study on the rotating speed of self- rotating twisted tape inserted tubes. Chin J Mech Eng (Engl Ed)2007;18:1970–3.

[10] Li J. Experimental study on the working characteristics of built-in aluminum self-rotating twisted tape heat exchanger tube. Guangxi University; 2006.

[11] Zhang L, Qian H, Xuan Y, Yu X. Numerical simulation of the three dimensional fluid flow and heat transfer of heat exchanger tubes with twisted tape insert. Chin J Mech Eng (Engl Ed) 2005;41:66–70.

[12] Zhang L, Qian H, Yu X, Xuan Y. Heat transfer enhancement of heat exchanger tubes with rotating twisted tape insert. Chin J Mech Eng (Engl Ed) 2007;43:139–43.

[13] Zhang L. Investigation on enhanced heat transfer mechanism and cleaning synamics of the rotating twisted tape. Nanjing University of Science & Technology; 2006.

[14] Feng ZF, Sun RJ, Lin Q Y. Numerical simulation of pressure drop characteristics in a circular tube with self-rotating twisted tape inserts. J Chin Guangxi Univ (Nat Sci Ed)2013: 657–62.

[15] Wang J. Experimental research on heat transfer and flow resistance of upward-low heat transfer tube with self-rotating aluminium twisted tapes. Guangxi University; 2008.

[16] Lin H. Study on the working characteristics and heat transfer enhancement of the polypropylene self-rotating twisted tape inside vertical heat exchanger tube. Guangxi University; 2007.

[17] Yu X, Yu T, Peng D. Twisted strip with oblique teeth to efficiently remove fouling and enhance heat transfer at low flowing velocity. Chin J Chem Eng 2005:750–3.

[18] Zhan S. Study on experiment and numerical simulation of flow field in a heat exchanger tube fitted with triangular groove twisted tape insert. Guangxi University;2012.

[19] Zhan S, Lin Q, Feng Z. Rotational and resistance characteristics in a circular tube fitted with triangular groove twisted-tape insert. Chin J Chem Equip Technol2012;33:36–9.

[20] Sun R. Experiment and simulation of heat transfer enhancement in a circular tube fitted with semicircle groove twisted tape. Guangxi University; 2013.

[21] Liu X. Experimental study of the heat transfer enhancement in a downing- channel tube fitted with regularly spaced twisted tape and coiled. Guangxi University; 2014.

[22] O u X. Experimental studies on working characteristics of helically twisted tape and numerical simulation analysis in vertical heat exchanger tube. Guangxi University; 2014.