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ENHANCEMENT OF HEAT TRANSFER THROUGH PIPE WITH THE HELP OF VARIOUS TYPES OF TURBULATORS – A REVIEW

Virendra Patidar[1], Nishant Vibhav Saxena[2]

[1]*M. Tech scholar , Dept. of Mechanical Engineering, MIT College, Bhopal (M.P.), India*
[2]*Assistant Professor (HOD), Dept. of Mechanical Engineering, MIT College, Bhopal (M.P.), India*

Abstract - *Heat transfer rate can also be increased with the help of some active or passive technique of enhancement of heat rate in a heat exchange as it gives a vital role in several industries. The changes which are done by using techniques convert simple natural heat exchanger to augmented heat exchanger. The intention to present this paper is to analysis the change in the heat transfer rate due to change in enhancement technique by a baffled twisted tape inserts in a heat exchanger by the different literature reviews .*

***Key Words*: Heat exchanger, modified baffled twisted tape(TT), enhancement of heat transfer**

1.INTRODUCTION

In a classification based on the nature of heat exchange process heat can be exchanged by three ways out of which direct contact or open heat exchanger and regenerator have their limited uses but third one which has wide range of other classification is recuperator.

At present, the technology of the twisted tape insert is widely used in various industries. Insertion of twisted tape in a tube provides a simple passive technique for enhancing the convective heat transfer by introducing swirl into the bulk flow and by disrupting the boundary layer at the tube surface due to repeated change in surface geometry. The system has followed type of flow arrangements and geometric dimension with twisted tape.

1.1 Twisted tape:

In general a twisted tape is a metallic strip having twist from its central axis whose design depends only on three main factors which are material of strip, pitch of the twist and the twist ratio which is define by the ratio of the pitch length to the inside diameter of the tube but this is some old era. Now the modified twisted are the replacement of the plane twisted tape. Some of the modified twisted tapes are the tapes with attached baffles, slotted tape or tape with holes etc.

The simple heat exchanger equation for the convective heat transfer between a pipe and a fluid is Newton's Law of Cooling:

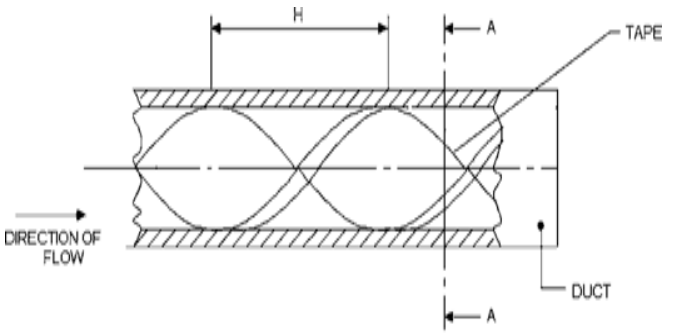


Fig 1 simple twisted tape

$$q'' = h\,(To - T\infty)$$

The symbols q'', h, T_o, and $T\infty$ represent the heat wall heat flux, the heat transfer coefficient, the temperature of the flat plate and the temperature of the fluid respectively.

The basic concept of using twisted tape is to convert laminar flow to turbulent flow which increases the rate of heat transfer termed as tabulator .there are lots of techniques which overcome the laminar flow to get turbulence in a pipe flow but the few of them can manage mass flow rate which is also the main factor in heat exchanger. For the free convection circumstances three main dimensionless numbers are

Nu no. $Nu = hl/k$

Grashof number $Gr = l^3\beta\rho^2\Delta t/\mu^2$

Prendtl number $Pr = \mu c_p/k$

For the long cylinder which is describe by length of the pipe is grater then the sixty times of the diameter of the pipe the empirical correlation is given by

Laminar flow $10^4 < Gr.Pr < 10^9$

and $Nu=0.53(Gr.Pr)^{0.25}$

Turbulent flow $10^9 < Gr.Pr < 10^{12}$

and $Nu=0.13(Gr.Pr)^{0.33}$

Other part in the heat exchanging processes overall heat transfer coefficient is also be taken as the important factor which is defined by

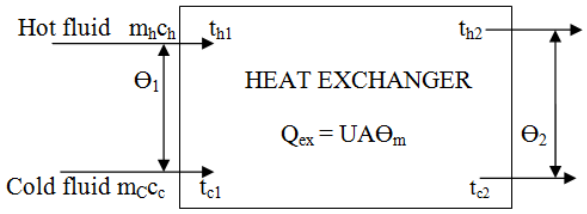


Fig 2 Block Diagram of Heat Exchanger

For hot fluid $Q_h = m_h c_h (t_{h1} - t_{h2})$

For cold fluid $Q_c = m_c c_c (t_{c1} - t_{c2})$

2. LITERATURE REVIEW

A tube inserted with a twisted-tape performs better than a plain tube, and a twisted-tape with a tight twist ratio provides an improved heat transfer rate at a cost of increase in pressure drop for low Prandtl number fluids. This is because the thickness of the thermal boundary layer is small for a low Prandtl number fluid and a tighter twist ratio disturbs the entire thermal boundary layer as discussed by different authors.

Kurhade Anant Sidhappa et. al [1] works in the condition of force convection by using twisted tape insert of width 16 mm thicknesses 1.2mm, length 0.5m and twist ratio 5.5, 6.5, 8.5 with circular holes of diameter 6mm and conclude that for Re no.range 2000 to 12000, the Nussult number for twisted tape insert with twist ratio 8.5,6.5 and 5.5 was found to be 23.99%, 25.64% and 29.32% respectively also the Friction factor is increased approximately by 0.20%, 0.2673 % and 0.4545 % with twist ratio 8.5, 6.5 and 5.5 respectively.

Avinash Savekar et. al [2] Give a Analysis of Heat Transfer in Pipe with Twisted Tape Inserts to understand the effect of change in pitch of twisted tape on the flow physics, results of Re no.800 and twist ratio 2, 3, 4 and 5 are considered and conclude the variation of twist ratio and Re no.on heat transfer and flow characteristics using twisted tape inserts and also the heat transfer increases with decrease in twist ratio and increase in Reynolds number.

G.Nagarajan et. al [3] found in double pipe heat Exchanger of diameter 0.015 m and length of 2.5 m with variable twisted type insert in ANSYS fluent that a trend of increase in heat transfer with the provision of insert on the heat exchanger. The heat transfer was found to increase as the Re no.was varied over the range. The result shows that effect of insert on the enhancement of heat transfer depends on both the pattern of insert and Re no.of the flow.

N.A.Uzagare et. al [4] after analyzing heat transfer augmentation using V-Jagged twisted tape gives The heat transfer enhancement, thermal performance and friction factor characteristics of V jagged twisted tape turbulator inserted tube will be investigated experimentally.

D.S. Nakate et. al [5] Performed for heat exchanger by inserting twisted tape turbulators with baffle For same twist ratio, Baffled reduced width twisted tape with holes & Baffled reduced width twisted tape shows higher heat transfer coefficient & friction factor increase because of higher degree of turbulence created also gives higher heat transfer coefficient than the reduced width twisted tapes.

Snehal S. Pachegaonkar et. al [6] gives the result for the performance analysis of double pipe heat exchanger of inner pipe inner diameter 16.5mm, outer diameter 21.5mm and outer pipr inner diameter 42mm, outer diameter 48.5mm with Annular M.S. Twisted Tape Insert of Width 10mm, pitch 67mm,107mm, twist ratio 6.7, 10.7 , tape thickness 1.4mm length of 1.5m. For plain double pipe heat exchanger result shows linear tendency, since the Nu no.is directly proportional to Reynolds number. The results for heat exchanger with twisted tape has parabolic tendency From the results obtained it is concluded that the best performance with twisted tape inserted into annulus of double pipe heat exchanger is obtained at twist angle 450 due to more swirl and turbulence induced by tape insert.

Heydar Maddah et. al [7] work to find out effect of twisted-tape turbulators and nano-fluid on heat transfer in a double pipe heat exchanger of the inner and outer diameters of the inner tube was 8 and 16 mm, respectively, and cold and hot water were used as working fluids in shell side and tube side. The twisted tapes were made from aluminum sheet with tape thickness (*d*) of 1 mm, width (*W*) of 5 mm, and length of 120 cm. Titanium dioxide nano particles with a diameter of 30nm and a volume concentration of 0.01% (v/v) were prepared. The conclusion given by them is increases in the heat transfer and overall heat transfer coefficient about 12% and 20% also increases in the efficiency about 10% and 30% as With increases in the friction factor about 2% and 2.5% as compared to the base fluid.

K. Hata et. al [8] studied twisted tape induced swirl flow pressure drop and heat transfer in vertical circular tube by computational method. Heat flow in this type of exchanger found exponentially increased whereas twisted tape induced pressure drop. Experiment carried out for mass velocity G= 4120 to 13570 kg/m2 /s, inlet temperature 300.13 to 305.78 K and pressure 866.52 to 945.86 kPa by water loop flow. The result found by them are inner and outer surface temperature for three section become gradually higher with an increased in heated length from t leading edge of the tube with twisted tape insert, whereas the heat flux almost constant for each position of the section.

Dr. A. G. Matani et. al [9] work by using the twisted tapes made of mild steel and have tape width of 10 mm, 15 mm & 20mm. tape thickness of 0.8mm, and tape length of 900 mm. also a wire coil having pitch of 30 mm is used to generate co-

swirl. All tapes were prepared with different twist ratios, = 3.5, 2.66 and 2.25 respectively and conclude that for the inserted tube, the pressure drop tends to increase with the rise in mass flow rate while the friction factor and performance factor give the opposite trends.

Pawan A. Sawarkar et. al [10] done an experimental analysis of augmentation in heat transfer coefficient using TT with semi-circular cut and conclude that the semi-circular cut TT offered a higher heat transfer rate and friction factor compared to the smooth tube and plain TT also Nu no. increases with decrease in twist ratio along with increase in cut radius. Friction factor decreases with increase of Re no. with increase in cut radius with aluminum TT of width 25mm, thickness 3mm, twist ratio 3.5 and 5.3 and radius of cut is 5mm and 10mm.

Sami D. Salman et. al [11] Give a CFD Analysis of Heat Transfer and Friction Factor Characteristics in a Circular Tube Fitted with Quadrant-Cut Twisted Tape Inserts in which Tube Test section is of steel having Inner tube diameter and Outer tube diameter 25.4mm33mm respectively and length of tube is 1.8mand Twist tape of Aluminum with twist ratio 2.93, 3.91, 4.89 thickness 0.8mm and width 24.5 mm and conclude The data are well matched with the literature correlations for plain tube with a discrepancy less than +8% for Nu no. and +10% for friction factor.

Al Amin et. al [12] gives the Enhancement of heat transfer using a Rotating TT Insert in a Copper pipe of 4ft length, 39 mm inner diameter and give the effect of Re no. for different flow rates on Nu no. also Nu no. for tube with tape insert is comparatively higher than Nu no. in smooth tube. The value of Nu no. keeps on increasing significantly as the RPM of the twisted tape is increased and With increase of both RPM and Re no, higher values of Nu no. can be obtained.

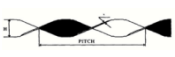
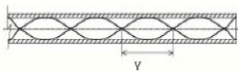
S. Naga Sarada et. al [13] Work on an experimental investigation of the potential of reduced-width TT inserts to enhance the rate of heat transfer in a horizontal circular tube with an inside diameter of 27.5mm with air as the working fluid. The Re no. varied from 6000 to 13500. The enhancement in heat transfer with TT inserts compared to the plain tube varied from 36 to 48% for full-width and 33 to 39% for reduced-width 22 mm inserts and the maximum friction factor rise about 18% for 26mm and only 17.3% for the reduced-width inserts compared to the plain tube. Also the overall enhancement ratio of the tubes with full-width TT inserts is 1.62 for full-width 26mm tape, and 1.39 for reduced-width 22mm twisted tape inserts.

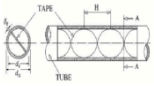
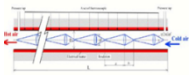
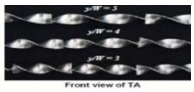
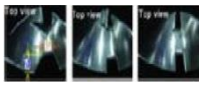
S.D.Patil et. al [14] give a analysis of twisted tape with straight winglets to improve the thermo-hydraulic performance of tube in tube heat exchanger in his setup a double pipe heat exchanger consisting of a calming section which is of a Plain copper tube with dimensions of 1600mm length, Inner tube-20.5mm ID, and 26mm OD; Outer MS pipe-52mm ID, and 60 mm OD. The outer pipe was well insulated using 200mm diameter glass wool with decrease in twist ratio, heat transfer coefficient increases but at the same time pressure drop also increases. For same twist

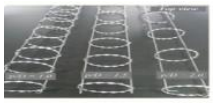
ratio, Straight delta winglets shows greater heat transfer coefficient & friction factor than the value we got form inserts Typical TT because of increased degree of turbulence created.

Some more principal findings are arranged in table 1.

Table -1: Literature Review According to the Geometry used in TT

S. NO.	Authors Name	Name of Turbulator and Geometry	Specification and condition	Principal finding
Twisted Tape Turbulator (TT)				
1	Cengiz Yildiz[et al [15]	Typical twisted tape 	3400<Re<6900	Increasing in pitch size increases the rate of heat transfer and increasing in pressure drop is also considerable.
2	Yadav Anil Singh [16]	Half length twisted tape turbulator 	twisted ratio for half length is 7, thickness is 0.8mm, Length=2m (2 piece)	A significant improvement in heat transfer coefficient by 40% for half length twisted tape. On equal mass flow rate basis, the heat transfer of half length twisted tape is maximum followed by smooth tube. .
3	P.K. Nagarajan et al. [17]	Full length twisted tapes 	Twist ratio 6,8,10 1192<Re<2534	The heat transfer enhancement and friction factor increases with decrease in twist ratio and the lower the twist ratio performs much better than the higher twist ratio insert.

4	Naga Sarada et al. [18]	Varying Width twisted tape 	width range=10,14,18,22,26 Pitch ratio=3,4,5 6000<Re<13500	Heat transfer increases with insertion of twisted tape as compared to plain tube Reduction in tape width causes reduction in Nu no.as well as friction factor.
5	S.K. Saha et al.[19]	Regularly spaced twisted tape 	Twist ratio =2.5<y<5,45<Re< 1150.	Heat transfer rate increased regularly spaced twisted tape.
6	C.B. Sobhan et al. [20]	Spiral Turbulator 	pitch 2.5, 4.0, 5.5 ,7.0	Heat Exchanger gives Substantial enhancement in overall heat transfer, additional expenditure in pumping power, friction losses high.
7	S. Eiamsa-ard et al [21]	Twisted tape with center wing 	Twist ratio y=3, angle of attack b 431, 531 and 741 5200<Re< 22000	With the largest angle of attack gave the highest Nu no.(Nu), Friction factor (f) as well as thermal performance factor.
8	M.R. Salimpour and S Yarmohamma di [22]	Twisted tape inserts 	Twist ratio=4,7,10,14	The insertion of twisted tape inside horizontal tubes increases the condensing pressure drop increases with both refrigerant mass velocity and vapor quality.
9	S. Eiamsa-ard and P. Promvonge et al [23]	Diamond shaped turbulators 	Cone angle= 150,300,450 tail ratio= 1, 1.5, 2 , 3500<Re< 16500	The increase in the heat transfer rate with increasing the cone angle and decreasing the tail length ratio.
10	P.Seemawute and S. Eiamsa-ard [24]	Tape consisting of alternate Axis 	Twist ratio 3, 4,5 3000<Re< 10000	It is found that the tube with TA Provides a better fluid mixing in the tube than those TT which leads to higher heat transfer rate and also friction factor.
Winglet twisted tape turbulator				
11	S. Eiamsa-ard [25]	Delta winglet twisted tape 	cut ratio = 0.11, 0.21, 0.32 3000<Re< 27000	The Nu no.and friction factor in the test tube with delta-winglet twisted tape are noticeably higher than those in the plain tube and also tube with typical TT.
12	K. Wongchare and S. Eiamsa-ard [26]	Twisted tapes with alternate axes and triangular rectangular and trapezoidal wings 	Wing-chord ratio (d/w) of 0.1, 0.2 and 0.3, twist ratio=4	Nusselt number, friction factor and thermal performance increase with increasing wing chord ratio
13	P. Murugesan [27]	Twisted tape with trapezoidal cut 	2000<Re<12000 Twist ratio y= 4.4 and 6.0	The mean Nu no.for trapezoidal cut twisted tape higher than typical twisted tape
Extended surfaces twisted tape turbulator				
14	P. Murugesan [28]	Twisted tape consisting wire nails 	2000<Re<12000 Twiste ratio =2.0, 4.4, 6.0	Common swirling flow generated by p-TT. Additional turbulence offered by the wire nails.
15	S. Selvam et al. [29]	Twisted tape with pins 	10000 <Re<23000 twist ratio y=3.39, 4.29, 5.71	71 Nu no.increases with the decrease of the ratio y/w . The friction factor also increases with the decreasing twist pitch.
Coil turbulator				
16	P. Promvonge [30]	Twisted tape and wire coil turbulator	3000<Re< 18000	The combined wire coil and twisted tape turbulator are compared with a smooth

				tube at a constant pumping power a double increase in heat transfer especially at low Re no. values for the lowest value of the coil spring pitch and twist ratio.
18	C. Thianpong [31]	Twisted ring turbulator 	Twisted ring ratio =0.05, 0.1, 0.15 Pitch ratio=1, 1.5 ,2 6000<Re<20000	For TRs, Nu no. and friction increases as width ratio increases and pitch ratio decreases.
19	D. Munoz-Esparza and E.Sanmiguel-Rojas [32]	Wire coil in pipe 	500<Re<600	The increase of the non dimensional pitch, p/d decreases the friction factor.
Spiral turbulators				
20	S.Eiamsa-ard and P. Promvonge [33]	Combined wavy surfaced wall and helical tape 	, 3000<Re<9200	The heat transfer rate can be substantially improved by using both the wavy surfaced wall and the helical tape.

3. CONCLUSIONS

As the heat exchanger plays a vital role in our daily life. It needs to be enhancing the rate of heat transfer with some technique. Twisted tape is used as the passive techniques to improve the efficiency of a heat exchanger and after this era there is a scope of more in this field for the enhancement of heat transfer and pressure drop with different range of Nu no, Pr no with improvement on heat transfer efficiency based on modified triangular baffled twist-straight turbulators. It can also used by conducting an experiment. In comparison with the previous research proposal methodology, this one is much more complicated. We can change the dimension of modified baffled twist-straight turbulator for different result analysis like different twist ratio with different material of tape and flow data.

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