

**Heat Transfer Enhancement Using Twisted Tape Insert: A Review**<sup>1</sup>Harshit Dharsandia, <sup>2</sup>Kruten Patel<sup>1</sup> PG scholar, Parul University,  
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**Abstract**—For energy conservation & also beneficial point of view we have to concentrate on heat transfer enhancement. So, for that we have to improve effectiveness of heat exchanger by reducing size as well as increasing heat transfer rate. Many research have been done as well as going on to improve heat transfer rate, we can be classified these research into three categories like (a) Active method (b) Passive method & (c) Compound method. Here we are focusing on passive method, in this method we can change geometry as well as we can use various insert to improve heat transfer rate. Many research has been conducted on different types of twisted tape as well as many correlations were also found out to increase heat transfer rate. In this study, review on work done in the area of enhancement of heat transfer rate using various types of twisted tape has been carried out. Based on literature survey various experiments & numerical correlations are discussed here. These survey shows that further improvement in heat transfer rate in heat exchanger system can be carried out by implementing best geometry of twisted tape based on which fluid used.

**Key Words**—Heat transfer, Twisted tape insert, Pressure drop, Nusselt number.

**I. INTRODUCTION**

Efficient heat transfer system is one of the important requirements in energy conservation. The enhancement of heat transfer leads to augmentation of high heat flux. Apart from this, enhancement in heat transfer rate also leads to several advantages like reduction of heat exchanger size and temperature driving force etc. The reduced size of heat exchanger is quite important from economic point of view whereas reduction of temperature driving force leads to increase second law efficiency and minimization of entropy generation or minimum energy destruction. In addition to this, high heat transfer rate is beneficial due to the fact that heat exchanger can be operated at low velocity and gives considerably higher heat transfer coefficient. Consequently, low operating pressure drop is achieved and operating cost is considerably reduced. In order to improve the efficiency of heat exchangers, it is very important to improve thermal contact and decrease the pumping power. These benefits associated with heat transfer enhancement force to explore different techniques/methods to improve thermal performance of heat exchangers.

Heat transfer enhancement is always an important matter of concern since the enhancement of heat transfer rate leads to increase the performance of system which is quite important in various heat transfer applications. Twisted tapes are well known heat transfer enhancement devices and several correlations of heat transfer and pressure drop have been developed for different types of twisted tapes. The enhancement of heat transfer is obtained by developing swirl flow of the tube side fluid, which gives high velocities near boundary and fluid mixing and consequently high heat transfer coefficient.

**II. HEAT TRANSFER ENHANCEMENT USING TWISTED TAPE**

Broadly speaking, heat transfer enhancement is categorized

in main three methods which are: 1) Active method, 2) Passive method & 3) Compound method.

In active method, external force is applied to increase heat transfer rate. Examples of active method can be mentioned as reciprocating plungers, implementing magnetic field for flow disturbance, using surface or flow vibration and also applying electromagnetic fields.

In passive method, no external force is applied for heat transfer enhancement. Geometrical modifications and various inserts play an important role in heat transfer enhancement.

In compound method, combinations of active & passive method are used to increase heat transfer enhancement.

In case of passive method various inserts are used like: twisted tape insert, extended surfaces, wired coils, other kind of turbulators.

**Smith Eiamsa-ard & Promvonge<sup>[1]</sup>** carried out an experiment investigation to study heat transfer enhancement using regularly spaced helical twisted tape insert. Reynolds number is in the range of 2300 to 8800. In this experiment, full length helical twisted tape & regularly helical twisted tapes are used & results are compared. So, from results it is seen that if here full length twisted tape with core rod used heat transfer increases 160 %, if full length twisted tape without core rod used then heat transfer increases 150 %, if regularly spaced helical twisted tape used then heat transfer increases 145 % compare to plain tube.



Fig. 1 Helical twisted tape with core rod



Fig. 2 Helical twisted tape without core rod

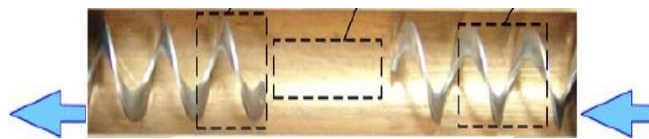


Fig. 3 Regularly spaced helical twisted tape

Smith Eiamsa-ard, Promvong<sup>[2]</sup> carried out an experimental investigation to evaluate heat transfer enhancement using combined conical ring & twisted tape insert. In this experiment two type of heat transfer enhancement devices are used, one is conical ring & other is twisted tape as shown in below figure.

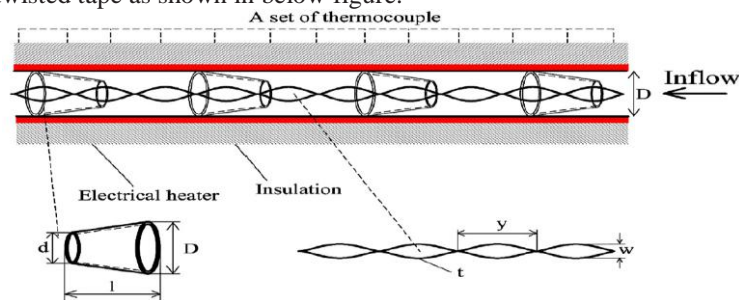


Fig. 4 Test tube fitted with conical-ring turbulator and twisted-tape insert

From this experiment, it is found that smaller twist ratio is, the larger the heat transfer & friction factor for all Reynolds number the average heat transfer rates from using both the conical-ring and twisted-tape for twist ratio,  $Y=3.75$ , and  $7.5$ , respectively, are found to be 367% and 350% over the plain tube. However, the friction factor from using both devices also increases considerably.

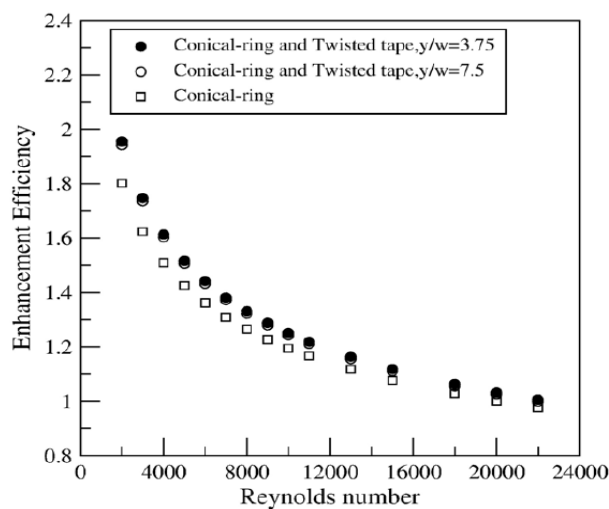
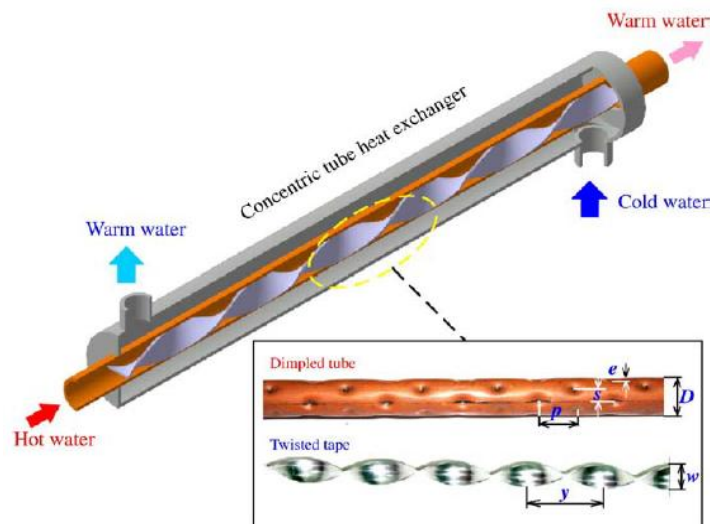


Fig. 5 Variation of enhancement efficiency with Reynolds number

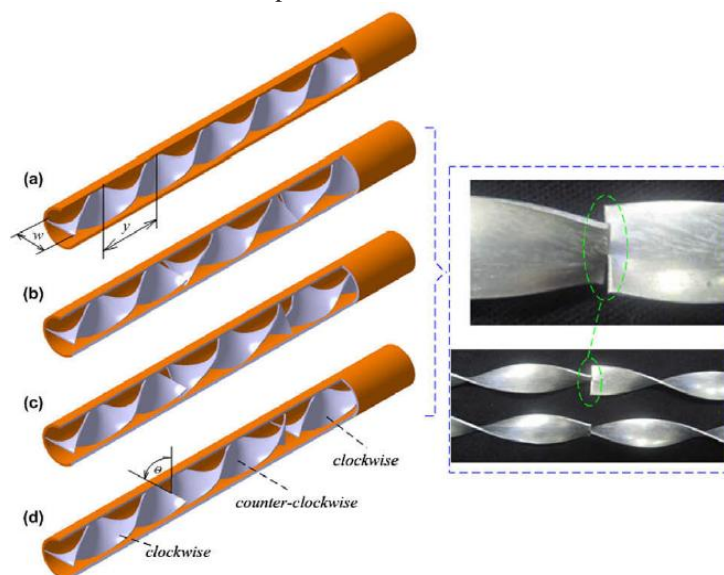
So, from above graph it can see that for twist ratio  $Y = 3.75$  heat transfer enhancement is more compare to other twist ratio. **ChinarukThianpong, Petpices Eiamsa-ard, Khwanchit Wongcharee, Smith Eiamsa-ard**<sup>[3]</sup> carried out an experimental investigation to evaluate heat transfer enhancement in dimpled tube fitted with twisted tape insert using air as working fluid. Dimpled tube with twisted tape insert is as shown below figure.

The influences of the pitch ratio and twist ratio on the heat transferrate and friction factor characteristics have also been investigated. A dimpled tube in common with a twisted tape has significant effects on the heat transfer enhancement and friction factor. The heat transfer and friction factor are increase with decreasing both of pitch ratio (PR) and twist ratio ( $y/w$ ). Depending on the pitch ratio and twist ratio, the heat transfer rate and friction factor in the dimpled tube with twisted tape, are respectively 1.66 to 3.03 and 5 to 6.31 times of those in the plain tube. The empirical correlations for the Nusselt number and the friction factor based on the present experimental data are also presented.



**Fig. 6 Dimpled tube with twisted tape insert**

**Smith Eiamsa-ard, Promvonge**<sup>[4]</sup> carried out an experimental investigation to evaluate heat transfer enhancement using alternate clockwise & counter clockwise twisted tape insert.

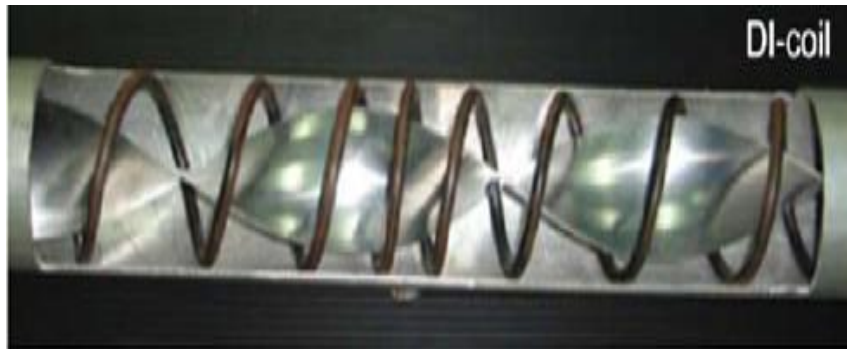


**Fig. 7 Test tube fitted with three different twisted tape insert**

The clockwise & counter clockwise twisted-tape with twist ratio,  $y/w = 3.0$  causes higher turbulence/swirl flow and yields heat transfer rate up to 90.5% over the plain tube. In addition, the C-CC twisted-tape provides higher Nusselt number and friction factor than the typical twisted-tape at about 12.8–41.9% and 12.5–41.5%, respectively. For the C-CC twisted-tape at  $y/w = 3.0$ , the Nusselt numbers are around 9–11% and 18.7–21.6% while the friction factors are about 23–26% and 47.3–51% higher than those with  $y/w = 4.0$  and 5.0, respectively. The heat transfer enhancement index ( $\eta$ ) tends to increase with decreasing Reynolds number and/or twist ratio ( $y/w$ ), but to decrease with reducing twist angle ( $\theta$ ). The highest enhancement index is around 1.4, 1.34 and 1.3 for  $y/w = 3.0$ , 4.0 and 5.0, respectively. In addition, the C-CC

tapes with twist angle  $90^\circ$ , provide the mean enhancement index higher than those with  $30^\circ$  and  $60^\circ$ , around 9.3% and 2.2%, respectively.

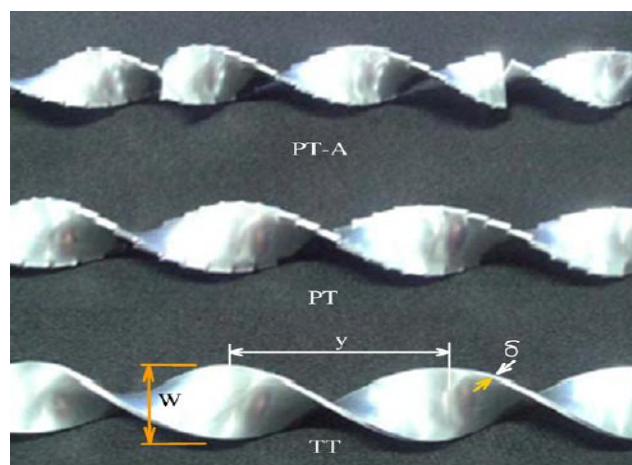
**S. Eiamsa-ard, P. Nivesrangsan, S. Chokphoemphun, P. Promvonge<sup>[5]</sup>** carried out an experimental investigation to evaluate heat transfer enhancement using twisted tape with constant/periodically wire coil insert.



**Fig. 8 Twisted tape with periodically wire coil insert**

In this paper, the heat transfer enhancement, friction factor and thermal performance factor behaviours in a tube equipped with the combined devices between the twisted tape (TT) and constant/periodically varying wire coil pitch ratio (D/DI-coil) are examined. The results from the combined devices are also compared with those from each device alone. At low Reynolds number, the experimental results reveal that the compound devices of the TT with  $Y=3$  and the DI-coil, provide the highest thermal performance which is around 6.3%, 13.7%, 2.4% and 3.7% higher than the wire coil alone, the TT alone, the TT with uniform wire coil, and the TT with D-coil, respectively. The correlations of the Nusselt number and friction factor for all parameters studied are also developed.

**Panida Seemawute, Smith Eiamsa-ard<sup>[6]</sup>** carried out an experimental investigation to evaluate heat transfer enhancement using peripherally cut twisted tape with an alternate axis. Experiment is conducted using water as a testing fluid. Twisted tapes which are used in experiment are as shown below.



**Fig. 9 Different types of twisted tape used in this experiment**

Under the similar conditions, heat transfer rate, friction factor as well as thermal performance in a tube fitted with PT-A are consistently higher than those in the tube equipped with PT, TT and also in the plain tube.

The combined actions induced by the PT-A are responsible for the increases of heat transfer rate and friction factor of around 50 to 184% and 6 to 11 times, respectively compared to those in the plain tube.

At constant pumping power, the thermal performance factors

obtained in the present study are as high as 1.25 for PT-A, 1.11 for PT and 1.02 for TT. Over the range studied, the maximum thermal performance factor for each twisted tape insert is achieved at the lowest values of Reynolds number ( $Re=5000$ ).



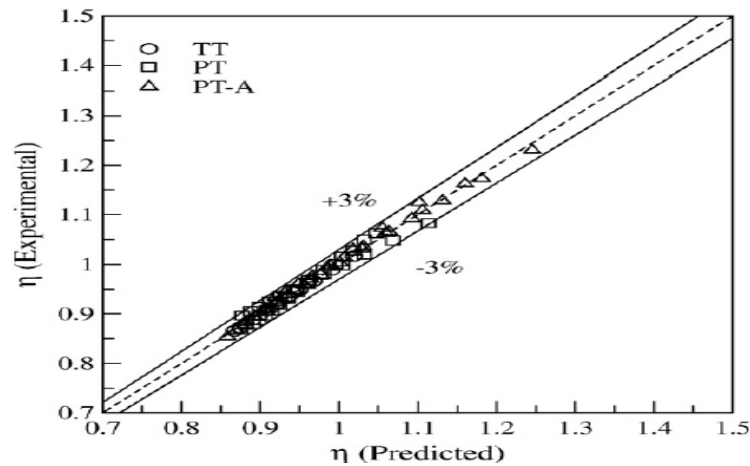


Fig. 10 Comparison of experimental and predicted values of thermal performance factor

C. Thianpong, P. Eiamsa-ard, P. Promvonge, S. Eiamsa-ard<sup>[7]</sup> carried out an experimental investigation to evaluate heat transfer enhancement using perforated twisted tape with parallel wings. The design of PTT involves the following concepts: (1) wings induce an extra turbulence near tube wall and thus efficiently disrupt a thermal boundary layer (2) holes existing along a core tube, diminish pressure loss within the tube. The parameters investigated were the hole diameter ratio ( $d/W = 0.11, 0.33$  and  $0.55$ ) and wing depth ratio ( $w/W = 0.11, 0.22$  and  $0.33$ ). Compared to the plain tube, the tubes with perforated twisted tape and simple twisted tape yielded heat transfer enhancement up to 208% and 190%, respectively. Perforated twisted with parallel wings is shown in below figure.

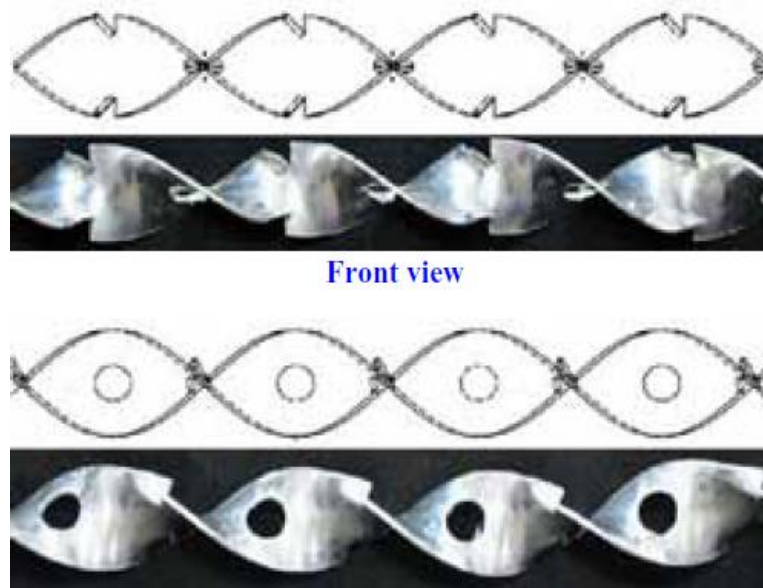


Fig. 11 Photograph & sketch of twisted tape with parallel wings

The results showed those heat transfer and friction factors were significantly influenced by the presences of wings and holes on perforated twisted tape with parallel wings. Both heat transfer and friction increased with the increase of wing depth ratio ( $w/W$ ) 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 wing depth ratio ( $w/W$ ) increased and hole diameter ratio ( $d/W$ ) decreased.

S. Eiamsa-ard & Pongjet Promvonge<sup>[8]</sup> carried out an experimental investigation to evaluate heat transfer enhancement using double sided delta wing tape insert with alternate axes. In the current work, the T-W formed on the tape was used as vortex generators for enhancing the heat transfer coefficient by breakdown of thermal boundary layer and by mixing of fluid flow in tubes. Figure shows the tape used in this experiment.

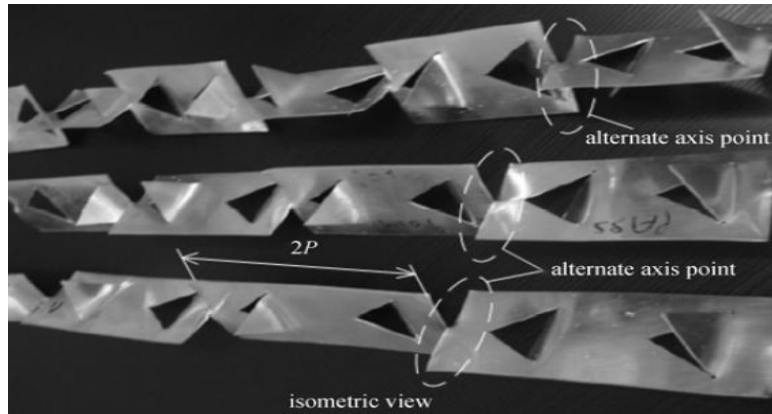


Fig. 12 Geometry of tape with different centre wing arrangement

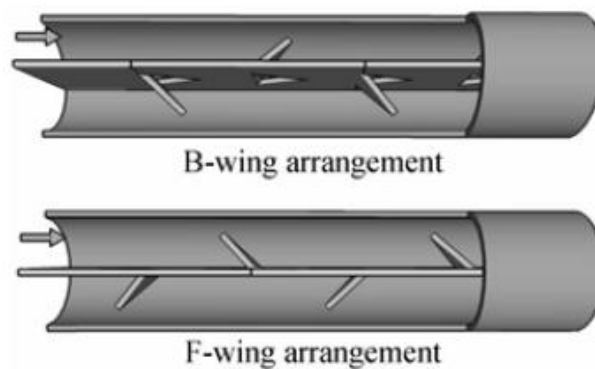


Fig. 13 B & F wing arrangement

The heat transfer of the T-W and T-WA increases when the wing pitch ratio,  $e_p$  decreases and the wing width ratio,  $e_w$  increases. It is found that the F-wing performs better heat transfer rate than the B-wing depending on  $e_p$  and  $e_w$  values and its thermal performance is 3.6% higher. For the T-WA with F-wing, the thermal performance increases with the reduction of  $e_p$  and Reynolds number values and with rising  $e_w$ . The thermal performance factor of T-WA with F-wing varies between 0.98 and 1.29; 0.93 and 1.22; and 0.88 and 1.16 for  $e_p = 0.75, 1.0$  and  $1.25$ , respectively.

**Smith Eiamsa-ard, Vichan Kongkai paiboon and Kwanchai Nanan<sup>[9]</sup>** carried out an experimental investigation to evaluate heat transfer enhancement using twisted tape fitted with circular ring. The circular-ring turbulators were individually employed and together with the twisted tape swirl generators in the heated section of the tube. Three different pitch ratios ( $l/D = 1.0, 1.5$ , and  $2.0$ ) of the CRT and three different twist ratios ( $y/W = 3, 4$ , and  $5$ ) of the TT were introduced. The experiments were conducted using air as the working fluid under a uniform wall heat flux condition, for the Reynolds number between 6000 and 20000. Figure shows twisted tape fitted with circular rings.

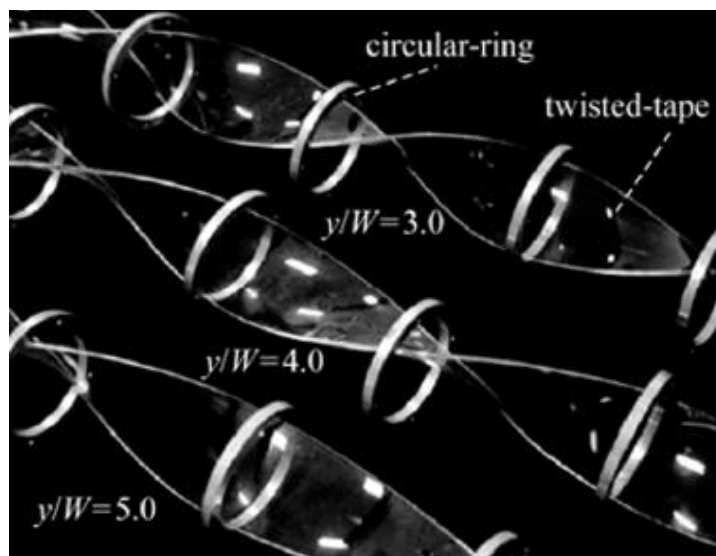
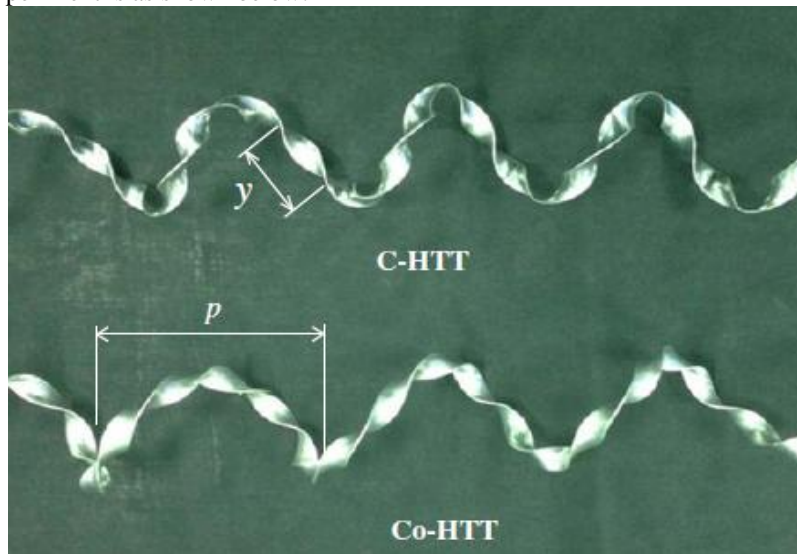


Fig. 14 Twisted tape fitted with circular rings

The order of heat transfer enhancement associated by the compound devices are about 2.36 to 4.47 times the plain tube which are accompanied by pressure loss ranging from 10.7 to 31.2 times, depending on the pitch ratio ( $l/D$ ) and twist ratio ( $y/W$ ) and Reynolds number ( $Re$ ) values. It is found that the heat transfer rate increases with increasing Reynolds number and decreasing pitch/twist ratio. Comparatively, the compound enhancement devices provide higher heat transfer rate than the circular-ring alone around 25.8%. At a constant pumping power, the thermal performance factor for all enhancement devices is found to be higher than unity. The maximum thermal performance factor of 1.42 is reached at the lowest Reynolds number,  $l/D \approx 1.0$  and  $y/W \approx 3.0$ . In addition, the correlations for Nusselt number, friction factor and thermal performance factor for the compound devices were developed as a function of the pitch ratio ( $l/D$ ) and twist ratio ( $y/W$ ), Prandtl number ( $Pr$ ) and Reynolds number ( $Re$ ) in this article.

**K. Nanan, K. Yongsiri, K. Wongcharee, C. Thianpong, S. Eiamsa-ard<sup>[10]</sup>** carried out an experimental investigation to evaluate heat transfer enhancement using helical twisted tape inducing co and counter swirl flow. Tape pitch ratio ( $p/D$ ) was varied between 1.0 and 2.0, while tape width ratio ( $w/D$ ) and twist ratio ( $y/w$ ) were fixed at 0.2 and 3.0, respectively. The experiments were performed for fully developed turbulent flow with Reynolds number range ( $Re$ ) between 6000 and 20,000 under uniform wall heat flux condition. Twisted tape which is used in this experiment is as shown below.



**Fig. 15 Helical twisted tape in co & counter arrangement**

At similar conditions, the use of C-HTT results in higher Nusselt number and friction factor but lower thermal performance factor than that of Co-HTT. A tape with smaller pitch ratio gives higher Nusselt number and friction factor but lower thermal performance factor. The use of C-HTT and Co-HTT ( $p/D = 2.0$ ) results in high thermal performance factors above unity for the entire Reynolds number range. In the range investigated, the maximum thermal performance factor of 1.29 is achieved by the use of Co-HTT at  $p/D = 2.0$  and Reynolds number of 6000.

### III. CONCLUSION

So, from our review we can conclude that if we are implementing different types of twisted tape then it increases swirling effect so that heat transfer rate is increases. Here pressure drop is also increases but compare to pressure drop we get more heat transfer rate increment.

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