Heat Transfer Enhancement By Twisted Tape Inserts: A Review

Kanika Joshi* & Vijay Singh Bisht
Faculty Of Technology, Department of Thermal Engineering ,UTU, Dehradun (UK)
*kanikakomal06@gmail.com & vsinghbisht5@gmail.com

Abstract
Heat transfer enhancement techniques refer to different methods used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques are used in heat exchangers. Some of the applications of heat exchangers are-in process industries, thermal Power plants, air-conditioning equipments, refrigerators, radiators for space vehicles, automobiles etc. These techniques broadly are of three types viz. passive, active and compound techniques. The present paper review mainly focus on the twisted tape heat transfer enhancement and its design modification towards the enhancement of heat transfer and saving pumping power.

Index Terms— Heat transfer augmentation, Passive methods, Tape inserts, Reynolds number, Friction factor, Twist ratio

1 INTRODUCTION

Nowadays, twisted-tape inserts have widely been applied for enhancing the convective heat transfer in various industries, due to their effectiveness, low cost and easy setting up. Energy and material saving consideration, as well as economical, have led to the efforts to produce more efficient heat-exchanger equipment. Therefore, if the thermal energy is conserved, the economical handling of thermal energy through heat-exchanger will be possible. The development of high performance thermal systems has stimulated interest in methods to improve heat transfer. The goal of enhanced heat transfer is to encourage or accommodate high heat fluxes. The heat transfer techniques enables heat exchanger to operate at smaller velocity, but still achieve the same or even higher heat transfer coefficient. This means that a reduction of pressure drop, corresponding to less operating cost.

2 DIFFERENT METHODS OF HEAT TRANSFER ENHANCEMENT

Generally, heat transfer enhancement methods are classified in three broad categories.[6]
Active method: This method involves some external power input for the enhancement of heat transfer;some examples of active methods include induced pulsation by cams and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, etc.
Passive method: These methods generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. For example, use of inserts, use of rough surfaces etc.
Compound method: Combination of above two methods.

3 TWISTED TAPE

Twisted tapes are the metallic strips twisted with some suitable techniques with desired shape and dimension, inserted in the flow. Following are the main categories of twisted tape which are analyzed.

Full length twisted tape: These tapes have length equal to length of test section.

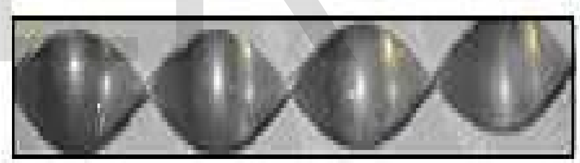

Fig. 1 full length twisted tape[6]

Varying length twisted tape: These are distinguished from first category with regards that they are not having the length equal to length of test section, but half length, ¾ th length, ¼ th length of section etc.

Regularly spaced twisted tapes: These are short length tapes of different pitches spaced by connecting together.

Tape with attached baffles: Baffles are attached to the twisted tape at some intervals so as to achieve more augmentation.

Fig. 2 tape with attached baffles[6]

Slotted tapes and tapes with holes: Slots and holes of suitable dimensions made in the twisted tape so as to create more turbulence.

Fig 3 slotted tape or tapes with holes[6]

Tapes with different surface modifications: Some insulating material is provided to tapes so that fin effect can be avoided. In some cases dimpled surfaced material used for tape fabrication.

Nomenclature

As heat transfer surface area, m2
D diameter, m
L length, m
u velocity, m/s
Q heat transfer rate, W
f friction factor
h heat transfer coefficient, W/m2K
k thermal conductivity, W/mK
l alternate length, m
ΔP Pressure drop, Pa
Nu Nusselt number
Re Reynolds number
y tape pitch length, m
W tape width, m
y/W twist ratio
l/y Ratio of alternate axes length to twist length
TT twisted tape
TA twisted tape with alternate length

4 A BRIEF GLIMPSE OF REVIEW OF WORK

Smith Eiamsa-ard[1] Influence of helical tapes inserted in a tube on heat transfer enhancement is studied experimentally. The maximum Nusselt number may be increased by 160% for the full-length helical tape with centered-rod, 150% for the fulllength helical tape without rod and 145% for the regularly-spaced helical tape, s = 0.5, in comparison with the plain tube.

Halit Bas[2] Flow friction and heat transfer behavior in a twisted tape swirl generator inserted tube are investigated experimentally. The twisted tapes are inserted separately from the tube wall. The effects of twist ratios (y/D = 2, 2.5, 3, 3.5 and 4) and clearance ratios (c/D = 0.0178 and 0.0357) are discussed in the range of Reynolds number from 5132 to 24,989, and the typical one (c/D = 0) is also tested for comparison. Uniform heat flux is applied to the external surface of the tube wall. The air is selected as a working fluid. The obtained experimental results from the plain tube are validated. The using of twisted tapes supplies considerable increase on heat transfer and pressure drop when compared with those from the plain tube. The Nusselt number increases with the decrease of clearance ratio (c/D) and twist ratio (y/D), also increase of Reynolds number.

P. Eiamsa-ard [3] reports on heat transfer enhancement and friction factor characteristics in the tubes inserted with rectangular-winged twisted tapes(TT-RWs). The wing-depth ratio (d/W) was varied from 0.1 to 0.3 while the tape twist ratio was kept constant at y/W = 4.0. According to the results, the TT-RW with d/W = 0.3 yields the highest Nusselt number which is around 100% higher than that of the plain tube.

B. Silapakijwongkul[4] In this work, effect of the tapes twisted in clockwise and counterclockwise arrangement (C-CC arrangement) on heat transfer and friction factor characteristics in a double pipe heat exchanger was investigated experimentally. The mean heat transfer rates obtained from using C-CC twisted-tape arrangement and original twisted-tape arrangement are found to be 219% and 204%, respectively over the plain tube.

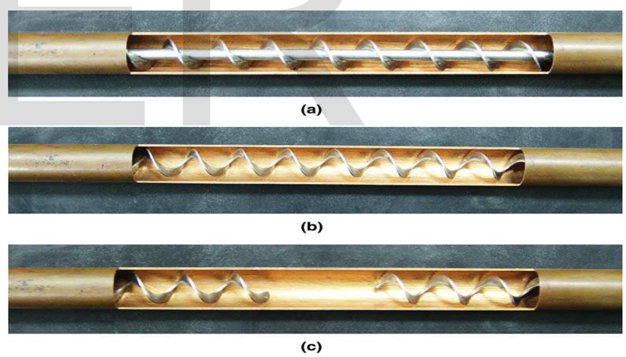

Fig.4 The inner tube fitted with various helical geometries insert:[2]

(a) Full-length helical tape with a rod(b) Full-length helical tape without a rod;(c) Regularly-spaced helical tape without a rod

C. Thianpong [7] This paper describes heat transfer enhancement attributed to helically twisted tapes (HTTs). Each helically twisted tape was fabricated by twisting a straight tape to form a typical twisted tape then bending the twisted tape into a helical shape. The experiments were performed using HTTs with three twist ratios (y/W) of 2, 2.5 and 3, three helical pitch ratios (p/D) of 1, 1.5 and 2 for Reynolds number between 6000 and 20,000. The conventional helical tape

(CHT) was also tested for comparison.The obtained results reveal that at similar conditions (y/W and p/D), HTTs give lower Nusselt number and friction but higher thermal performance factor than CHTs. Heat transfer rate and friction factor increase as the tape twist ratio and helical pitch ratio decrease, while the thermal performance shows opposite trend.

V. M. Kriplani [6] Heat transfer augmentation techniques refer to different methods used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques are used in heat exchangers. Some of the applications of heat exchangers are-in process industries, thermal Power plants, air-conditioning equ refrigerators, radiators for space vehicles, automobiles etc. These techniques broadly are of three types viz. passive, active and compound techniques. The present paper is a review of the passive augmentation techniques used in the recent past.

C. Thianpong[7] 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 with parallel wings (PTT) for Reynolds number between 5500 and 20500. 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). A typical twisted tape was also tested for an assessment. Compared to the plain tube, the tubes with PTT and TT yielded heat transfer enhancement up to 208% and 190%, respectively. The evaluation of overall performance under the same pumping power reveal that the PTT with d/W= 0.11 and w/W = 0.33, gave the maximum thermal performance factor of 1.32, at Reynolds number of 5500. Empirical correlations of the heat transfer, friction factor and thermal performance for tubes with PTTs were also developed.

S.S. Joshi[6] In this Study the overall performance of suitably designed concentric tube heat exchanger is analyzed with passive heat transfer augmentation technique. In the double pipe heat exchanger, different types of twisted tapes with different twist ratios are used. In addition to this, annular protrusions are used to augment the heat transfer by creating turbulence in the fluid flow. Effect of inserts on effectiveness of heat exchanger is analyzed for different Reynold Numbers. Simultaneously the friction factors for both inner and annular flow are analyzed.

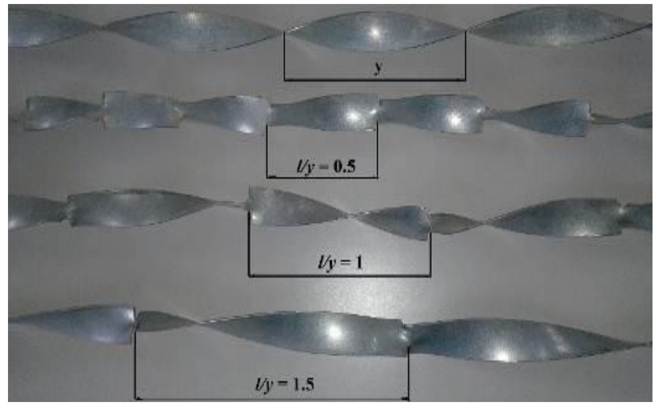

fig 5 Pictorial view of twisted tapes with alternate axes at different alternate lengths for y/W = 3[6]

5 CONCLUSION

This critical literature review reveals that there is wide applicability of twisted tape in tubular heat exchanger. Heat transfer rate is increase by using twisted type inserts then the plain tube used plain because twisted type tube insert is increase the turbulence of the flow. Also it is reduce the pressure drop and fouling factor.

6 REFERENCE

1. Smith Eiamsa- ard, PongjetPromvonge, “Enhancement of heat transfer in a tube with regularly-spaced helical tape swirl generators”.
2. Halit Bas, VeyselOzceyhan, “Heat transfer enhancement in a tube with twisted tape inserts placed separately from the tube wall.”, Experimental Thermal and Fluid Science 41 (2012) 51–58.
3. P. Eiamsa-ard, C. Thianpong and S. Eiamsa-ard, “Influences of Twisted-Tape with Parallel Rectangular- Wing on Thermal Performance of a Heat Exchanger.”
4. B. Silapakijwongkul, S. Eiamsa-ard and P. Promvonge, “Effect of clockwise and counterclockwise twisted-tape turbulators on heat transfer augmentation inside a double pipe heat exchanger.”
5. Smith Eiamsa-ard ,PongjetPromvonge, “Performance assessment in a heat exchanger tube with alternate clockwise and counter-clockwise twisted-tape inserts.” International Journal of Heat and Mass Transfer 53 (2010) 1364–1372
6. S.S.Joshi, V. M. Kriplani,“Review Of Heat Transfer Augmentation With Tape Inserts”,S.S.Joshi et al. / International Journal of Engineering Science and Technology (IJEST)
7. C. Thianpong, P. Eiamsa-ard, P. Promvonge, S. Eiamsa-ard, “Effect of perforated twisted-tapes with parallel wings on heat transfer enhancement in a heat exchanger tube.”
8. PanidaSeemawute, Smith Eiamsa-Ard, “Visualization of flow and heat transfer in tube with twisted tape consisting of alternate axis.”
9.”HEAT TRANSFER ENHANCEMENT” Anil Singh Yadav
10.”ENGINEERING HEAT AND MASS TRANSFER” Mahesh M. Rathore