Review on Heat Transfer Enhancement by using Twisted Tape Insert

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***Abstract*- Heat transfer devices have been used for exchange and enhancement of heat transfer rate in many industrial and domestic applications. There has been intensive effort to develop design of heat exchanger that can result in energy saving as well as material and other cost saving. Improvement techniques generally reduce the thermal resistance either by increasing the effective heat transfer surface area or by generating turbulence. Occasionally these changes are accompanied by enhancing the required turbulence by means of external Power which results in higher cost. The effectiveness of a heat transfer rate is calculated by the ratio of the change in the heat transfer rate to change in friction factor. The Various types of inserts are implemented in many heat exchanger devices. The different type of Geometrical parameters are width, length, twist ratio, twist direction, etc. that increase the surface area of heat transfer. For example insert with rectangular slot and without rectangular slot on twisted tape can give a better performance in both laminar and turbulent flow compared to twisted tape with rectangular slot and without rectangular slot twisted tape alone. This review paper provides a comprehensive review of passive heat transfer devices and their advantages for different industrial applications.**

Index Terms- Heat transfer enhancement, twisted tape, twist ratio, passive methods.

1. INTRODUCTION

To increase the efficiency of heat exchanger devices by decreasing the material cost and the difference for heat transfer so many methods that has to be used. There are different types of passive intensify method to increase heat transfer coefficient, twisted tape inserts are used. Twisted tapes belong to one important for swirl generator which mostly used for heat transfer enhancement. Twisted tapes with different tape geometries have been design in comparison with typical twisted tapes. The swirl flow (secondary flow) created by twisted tape fluid flow across the concentric tube, promotes greater turbulence and higher heat transfer coefficients. These types of techniques are used in heat exchangers. The applications of heat exchangers are in, thermal Power plants, air-conditioning equipments, radiators for space vehicles etc. These techniques broadly are of three types viz. passive, active and compound techniques.

Different Methods of Heat Transfer Enhancement
Heat transfer enhancement methods are classified in three types:
Active method: In this method required some external force input for the increasing the heat transfer rate. For example, use of force convection, etc.
Passive method: In this method use of surface or geometrical modifications to the flow canal by incorporating inserts or supplementary devices. For example, use of inserts, use of rough surfaces etc.
Compound method: It’s an arrangement of over the two methods.

2. TERMINOLOGY USED IN TWISTED TAPE

2.1 Pitch: The Pitch is defined as the distance between two points that are on the same plane, measured parallel to the axis of a Twisted Tape.

2.2 Twist Ratio: The twist ratio is defined as the ratio of pitch length to inside diameter of the tube

2.3 Overall Enhancement Ratio: The overall enhancement ratio is defined as the ratio of the heat transfer enhancement ratio to the friction factor ratio.

2.4 Nusselt Number: The Nusselt number is a measure of the convective heat transfer occurring at the surface and is defined as hd/k, where h is the convective heat transfer coefficient, d is the diameter of the tube and k is the thermal conductivity.

2.5 Prandtl Number: The Prandtl number is defined as the ratio of the molecular diffusivity of momentum to the molecular diffusivity of heat.

2.6 Thermo Hydraulic Performance: For a particular Reynolds number, the thermo hydraulic performance of an insert is said to be good if the heat transfer coefficient increases significantly with a minimum increase in friction factor Thermo hydraulic performance estimation is generally used to compare the performance of different inserts under a particular fluid flow condition.

3. REVIEW ON TWISTED TAPE

The present paper contributes for review of twisted tape inserts. The main objective of this paper is to review the work carried on plain twisted tape, modified twisted tape, and modified twisted tape geometry.

3.1 Azher M. Abed1, In this Experimentally Perform work Paper, forced convection heat transfer through a horizontal pipe built-in with/without twisted tape-inserts is numerically under a uniform heat flux condition. Water is used as a working fluid. Two type of twisted tape which inserts across a circular pipe Plan twisted tape (P-TT) and (V-cut) are carried out. The control of these parameters on the local, average Nusselt Number and the thermal performances were examined and compared with a plain pipe under similar conditions. After the performing the experiment result show that the heat transfer rate increases as(V-cut) twisted tape better than that of the (P-TT) with the twisted ratio (TR=4.0) is higher than that of the twisted ratio (TR=6.0). and also rates of heat transfer are always higher for the pipe supplied with twisted tapes as compared with the plain pipe, The friction factor which obtained from the pipe with twisted tape inserts is significantly higher than that of the plain pipe.

3.2 P. Eiamsa-ard1, in this paper Effects of the regularly-spaced twisted tape on the heat transfer, friction factor and thermal performance factor behaviours in a heat exchanger are reported along with those of a full length twisted tape. The full length twisted tapes with two different twist ratios (y¼ P/W¼ 6.0 and 8.0), and the regularly-spaced twisted tape with two different twist ratios (y¼ 6.0 and 8.0) and three free space ratios (s¼ S/P¼ 1.0, 2.0, and 3.0) were employed for comparative study. The experimental results show that heat transfer rate and friction increased with decreasing twist ratio and space ratio. At similar conditions, full length twisted tapes (s¼ 0) offered higher heat transfer rate, friction factor and thermal performance factor than regularly-spaced twisted tape ones (s¼1.0, 2.0 and 3.0).

3.3 Sombat Taman1 In this experiment author work on heat transfer enhancement in a round tube by insertion of double twisted tapes in common with 30° V-shaped ribs has been conducted. Air as the test fluid flowed through the test tube having a constant wall heat-flux with Reynolds number (Re). The combined V-ribbed twisted tape were obtained by incorporating V-shaped ribs into the edges of double co-twisted tapes having a similar twist ratio. The effect of pertinent V-rib parameters such as four relative rib heights, blockage ratio and a relative rib pitch at an attack angle of rib on thermal characteristics was investigated. An experimental investigation on thermal characteristics in a constant heat-fluxed round tube fitted with double V-ribbed twisted-tape for turbulent flow, Re from 5300 to 24,000 has been carried out. The highest heat transfer and pressure loss from the V-ribbed twisted tape inserts is found at the largest BR. Therefore, the use of the V-ribbed twisted tape is a promising enhancement device in the heat transfer improvement in a heating/cooling tube system.

3.4 Nemat Mashoofi1, the author is to investigate the ways to reduce the pressure drop and subsequently enhance thermal performance improvement factor of a heat exchanger equipped with twisted tapes. For this reason, axial perforated twisted tapes with different hole diameters are used instead of simple twisted tapes. The results indicated that the use of perforated twisted tape leads to a decrease in pressure drop and heat transfer rate.

3.5 Zhixian Ma1 Author worked on intense enhancement of the convective heat transfer, internal helical finned tubes are widely applied into the field of HVAC. An experimental setup was built for investigating single-phase flow characteristics of internal helical-rib roughness. The single-phase flow characteristics for water-ethylene glycol mixture in three internal finned tubes and a smooth tube were obtained. The nominal diameter of the two test tubes was 22.48mm and 16.662mm, the number of the fins was 60 and 38, the helix angle was 45 degrees and 60 degrees and the relative roughness was 0.022 and 0.053, respectively. Experimental results showed that the friction factor for the flow in the laminar regime of internal helical finned tubes is larger than that of the plain tube. The variation trend of the friction factor of the internal helical finned tube is remarkably different from that of the plain tube before the fully turbulent flow.

3.6 Ranjith1 In this experiment work, an attempt is made to analyse the performance of a modified double pipe heat exchanger with twisted tape induced swirl flow on both sides. The results obtained are validated using established correlations available in the literature. Insertion of twisted tape in double pipe heat exchanger improved the heat transfer coefficient on both tube side and annulus side of heat exchanger. Secondary flows induced by the twisted tape, enhanced cross stream mixing of the fluids, increase in the effective flow length and the fin effect of the twisted tape were the reasons behind improved performance of the heat exchanger. In both in tube and annulus, with Overall improvement Ratio around unity they also conclude that the heat transfer enhancement dominates over the pressure drop penalty incurred.

3.7 Alok Kumar1 Several researchers have worked on the passive approach of heat transfer enhancement in tube heat exchangers. Some of them tried to modify the surface by creating dimple or using wire coil of different cross-section, while some worked on core fluid disturbance by using some insert geometries such as twisted tapes. But the ultimate aim of all was to create some disturbance in the flow in order to obtain enhanced heat transfer. This paper focuses on comparison of some of the most commonly used insert geometries. Insert geometry selected for this comparison is collection of core fluid disturbance, surface modification and combination of both. Result shows that for the better thermal performance factor in a heat exchanger core disturbance and surface disturbance of fluid flow both play a significant role. In case of twisted tape with circular ring both the disturbances can be determined. But in case of twisted tape only core disturbance was observed. In case of circular ring insert the friction factor can be seen maximum because of the surface disturbance in the fluid layer, while the maximum heat transfer can be seen in case of twisted tape with circular ring in which both surface disturbance and core disturbance of the fluid can be seen.

3.8 C. Thianponga1 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. 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 wings and holes on PTTs. 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.

3.9 Bodius Salam1, An experimental investigation was carried for measuring tube-side heat transfer coefficient, friction factor, heat transfer enhancement efficiency of water for turbulent flow in a circular tube fitted with rectangular-cut twisted tape insert. A copper tube of 26.6 mm internal diameter and 30 mm outer diameter and 900 mm test length was used. A stainless steel rectangular-cut twisted tape insert of 5.25 twist ratio was inserted into the smooth tube. The rectangular cut had 8 mm depth and 14 mm width. A uniform heat flux condition was created by wrapping nichrome wire around the test section and fiber glass over the wire. Outer surface temperatures of the tube were measured at 5 different points of the test section by T-type thermocouples. Two thermometers were used for measuring the bulk temperatures. At the outlet section the thermometer was placed in a mixing box. The Reynolds numbers were varied in the range 10000-19000 with heat flux variation 14 to 22 kW/m2 for smooth tube, and 23 to 40 kW/m2 for tube with insert. Nusselt numbers obtained from smooth tube were compared with Gnielinski [1] correlation and errors were found to be in the range of -6% to -25% with r.m.s. value of 20%. At comparable Reynolds number, 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. 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.

3.10 Suvanjan1 Bhattacharyya Numerical investigation of heat transfer characteristics in a tube fitted with inserted twisted tape swirl generator is performed. The twisted tapes are separately inserted from the tube wall. The configuration parameters include the, entrance angle (a) and pitch (H). Investigations have been done in the range of a = 180˚, 160˚ and 140˚ with Reynolds number varying between 100 and 20,000. The numerical investigation shows that the larger entrance angle (a = 180˚) and small twist ratio (TR 18.0) can efficiently augment the rate of heat transfer, but also increase the flow resistance. This is because of the higher turbulence intensity. Also the periodic change of direction of swirl and also the heavy collision of the mixed fluids behind the varying location, lead to mixing of superior quality and better heat transfer, compared with the typical twisted-tape. The heat transfer enhancement efficiency (g) tends to decrease with increase Reynolds number..

4. CONCLUSION

This review has considered heat transfer and pressure drop investigations of the various twisted tape placed in heat exchangers. Summarizing all the literature data, such as heat transfer and pressure drop studies according to plain twisted tape, modified twisted tape, and modified twisted tape geometry The result also shows twisted tape insert is more effective in laminar flow, and pressure drop penalty is created during turbulent flow. In case of twisted tape with modified geometry, more turbulence is created during the swirl of fluid and gives higher heat transfer rate compared to plain twisted tape and modified twisted tape. The result shows that for modified twisted tape geometry, the heat transfer rate is higher with reasonable friction factor for both laminar and turbulent flow. These conclusions are valuable for the purpose of heat transfer enhancement in heat exchanger networks.

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