A REVIEW ON HEAT TRANSFER ENHANCEMENT USING TWISTED TUBE INSERTS IN A TUBE EXCHANGER

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ABSTRACT

Heat transfer enhancement is categorized into passive and active methods. Active methods need external power to input the process; in contrast, passive methods do not require any additional energy to improve the thermo hydraulic performance of the system.The present paper represents a comprehensive review that focused on heat transfer enhancement methods with twisted tube heat exchanger. The thermodynamic performance of heat exchange components is also affected by the flow conditions such as laminar or turbulence. The present review comprises investigations on the enhancement of heat transfer using twisted tube heat exchanger.

Keywords: Twisted tube heat exchanger, CFD, Reynolds Number, Friction factor

INTRODUCTION

Heat transfer enhancement is a process of increasing the heat transfer rate and thermo hydraulic performance of a system using various methods. The methods of heat transfer enhancement are employed for developing the heat transfer without affecting the overall realization of the systems significantly, and it covers a wide range of areas where heat exchangers are used for such functions as air-conditioning, refrigeration, central heating systems, cooling automotive components, and many uses in the chemical industry.

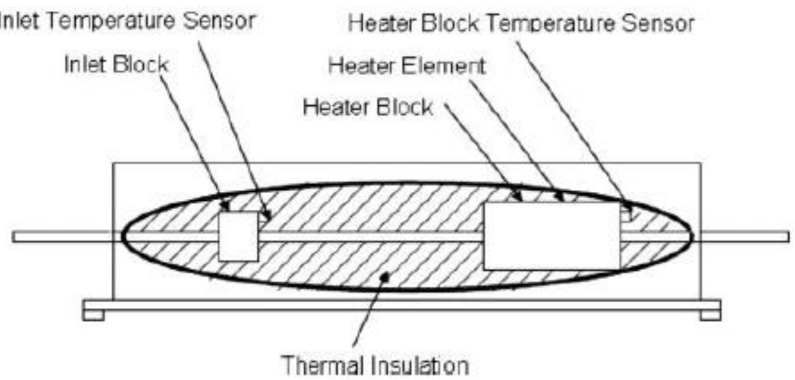

Figure 1: Heat Exchanger Unit

Twisted tube method

Twisted tube inserts are one of the most used enhancement methods of heat transfer. Twisted tube inserts increase both convective heat transfer and fluid friction in the flow region. They induce the turbulence and promote the swirl flow. Moreover, geometric configurations of twisted tube inserts can disturb the boundary layer; with this way, better heat transfer rate can be obtained. However, increment of the fluid friction can negatively affect the overall enhancement ratio for a heat exchanger tube. The performance of a heat exchanger with twisted tube inserts depends on pitch and twist ratios. In recent investigations, a lot of researchers have conducted both experimental and numerical studies to determine the optimal configuration in accordance with the ratios of pitch and twist.

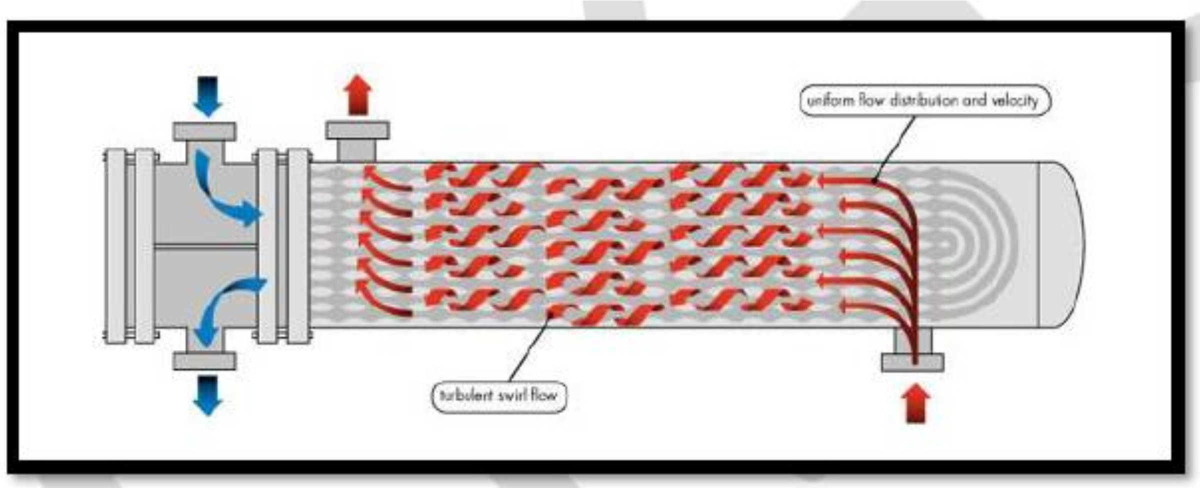

Figure 2: Shell and twisted tube heat exchanger

Heat Transfer Enhancement Techniques

- Heat transfer enhancement is one of the fastest growing areas of heat transfer technology.
- The technologies are classified into active and passive techniques depending on how the heat transfer performance is improved.
- A twisted tube is a typical passive technique that uses a specific geometry to induce swirl on the tube side flow.
- The twisted tube heat exchanger consists of a bundle of uniquely formed tubes assembled in a bundle without the use of baffles.
- Twisted tube technology provide highest heat transfer coefficient possible in tubular heat exchanger.
- In uniform shell side flow the complex interrupted swirl flow on shell side maximizes turbulence while minimizing pressure drop.
- The tube ends are round to allow conventional tube to tube sheet joints.
- Swirl flow in tube creats turbulence to improve heat transfer.
- By keeping the flow turbulent one secures a high heat transfer performance.

LITERATURE REVIEW

The heat exchanger is an important device in almost all mechanical as well as process industries. Hence from long time it has been keen interest of researchers to improve the performance of heat exchanger by enhancing heat transfer rate within the limits of certain pressure drop. The review of such techniques keeping focus on passive augmentation techniques is focus of all these papers. The twisted tapes were also been tasted by many of them for different twist ratios. These inserts are tasted individually and in different form and the results were compared.

Azmi et al. carried out the experimental investigation on forced convection heat transfer of nano-fluids along with twisted tape insert in a plane tube. Reynolds number range was varied from 5000 to 25000 with bulk temperature of 30oC in the investigation. The experiments were conducted for flow in a circular tube with twisted tapes of different twist ratios. The conclusion shows that the heat transfer coefficient of nano-fluids with twisted tape is higher in the water flow for the same twist ratio. The maximum heat transfer enhancement with twisted tape for TiO_2/water and SiO_2/water nano-fluids was in the range of 1% and 3% volume concentration.

Gawandare et al. different square jagged copper twisted tape inserts 3mm with 5.2, 4.2 and 3.2 twists respectively were experimentally studied for the heat transfer enhancement. The inserts create a high degree of turbulence resulting in an increase in the heat transfer rate and the pressure drop. The Reynolds number is varied from 5000 to 16000. The work includes the determination of friction factor and heat transfer coefficient for various twisted wire inserts with varying twists and different materials. The 3mm thick with 3.2 twists copper insert shows increase in Nusselt number values by 76% along with increase in friction factor by only 19.5% as compared to the smooth tube values.

Eiamsa-ard.et.al. the thermal performance assessment of the heat exchanger tube equipped with regularly spaced twisted tapes was studied. The full length twisted tapes with two different twist ratios ($y = p/w = 6.0$ and 8.0), and the regularly-spaced twisted tape (RS-TT) with two different twist ratios ($y = 6.0$ and 8.0) and three free space ratios ($s = S/P = 1.0$, 2.0, and 3.0) were employed for comparative study. The heat transfer rate and friction increased with decreasing twist ratio and space ratio. Full length twisted tapes ($s = 0$) recorded higher heat transfer rate, friction factor and thermal performance factor than RS-TT ones ($s = 1.0$, 2.0 and 3.0).

Nanan et al. studied the influence of perforated helical twisted-tapes (P-HTTs) on the parameters of thermal performance, heat transfer and friction loss characteristics under a uniform heat flux condition. The P-HTTs were obtained by perforating typical helical twisted-tapes (HTTs) with a view to obtain reduction in friction loss of fluid flow. Three P-HTT's of different diameter ratios (d/w) 0.2, 0.4 and 0.6, and three different perforation pitch ratios (s/w) 1, 1.5 and 2 were used in the experiment. The helical pitch ratio and twist ratio were fixed at $P/D = 2$ and $y/w= 3$. The range of Reynolds number were chosen between 6000 and 20,000. The experiments were repeated in the plain tube and the tubes with HTTs for assessment. The experimental results show that the use of P-HTTs helps the reduction of friction loss as compare to HTT. Thermal performance, heat transfer and friction factor increase as d/w decreases and s/w increases.

M. Bhuiya et al studied through experimentation the heat transfer and friction factor characteristics in turbulent flow for a tube fitted with perforated twisted tapes inserts with four different porosities of Rp = 1.6, 4.5, 8.9 and 14.7%.Herethe experiments were conducted in a turbulent flow regime with Reynolds number ranging from 7200 to 49,800 using air as the working fluid under uniform wall heat flux boundary condition. Nusselt number, thermal performance and friction factor in the tube with perforated twisted tape inserts was found to be 110 –340, 28–59% and110 – 360 higher than those of the plain tube values respectively.

Eiamsaard et al. reports an experimental investigation on heat transfer along with pressure drop characteristics of turbulent flow in a heating tube equipped with perforated twisted tapes with parallel wings (PTT). Reynolds number between 5500 and 20500 was recorded. 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). Heat transfer enhancement from 190% to 208% was reported in an assessment. Compared to the plain tube, the tubes with PTT and TT yielded. 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.

Dr. Abdullah et al. effect of different geometry twisted tapes in circular tube for turbulent flow heat transfer enhancement was experimentally tested. Effect of different geometry twisted tapes in circular tube for turbulent flow heat transfer enhancement. Use of Six types of twisted tapes with total length of 1200mm and diameter of 50mm were chosen for experimentation such as normal twisted tape regularly spaced twisted tape, triangular-cut twisted tape, and rectangular-cut twisted tape, and semi-circular-cut twisted tape, and drilled twisted tape. Variation of range of Reynolds number lies between 4500 to 23500. It was observed that the enhancement of heat transfer coefficient increases as the type of twisted tape changes from one to six, respectively.

Promvonge and Suwannapan a numerical analysis of laminar periodic flow and heat transfer characteristics was presented for a constant temperature-surface square channel mounted with 30° angled baffles of various pitches. The computations here were based for finite volume method for SIMPLE algorithm implementation. The heat transfer and fluid flow characteristics were presented for Reynolds number ranging from 100-2000in the channel hydraulic diameter. A pair of stream-wise counter– rotating vortex flow was generated by placing angled baffles repeatedly on the lower and upper channel walls with in–line arrangement. Effects of different pitch ratios (PR=P/H) with a single baffle height ratio of 0.2 on heat transfer and pressure loss in the channel were examined. The computation revealed that the pair of vortex flow leads to substantial increase in heat transfer rate over the test channel. The decrease in the PR also led to the rise of friction factor. The result showed that the optimum thermal performance enhancement factor of about 3.78 is found at PR=2.5.

Naga Sarada et al. experimental investigations display the result obtained of the augmentation of turbulent flow heat transfer in a horizontal tube of varying width twisted tape inserts with air as the working fluid. To get reduce reasonably sufficient pressure drops associated with full width twisted tape inserts and corresponding reduction in heat transfer coefficients, reduced width twisted tapes of widths ranging from 10 mm to 22 mm, in the tube having inside diameter of 27.5 mm were used. Experiments were conducted for plain tube with/without twisted tape insert at constant wall heat flux and different mass flow rates. Three different twist ratios (3, 4 and 5) each with five different widths (26-full width, 22, 18, 14 and 10 mm) respectively were used. The Reynolds number variation was calculated from 6000 to 13500. The enhancement of heat transfer with twisted tape inserts as compared to plain tube varied from 36 to 48% for full width (26mm) and 33 to 39% for reduced width (22 mm) inserts.

Murugesan et al. from the experimentation it was investigated the heat transfer and 'f' characteristics of trapezoidal cut TT with y= 4.0 and 6.0. It was reported that there was a significant increase in heat transfer coefficient and 'f' for tape with trapezoidal cut.

Siva Rama Krishna et al. reports on the investigation of heat transfer characteristics of circular tube fitted with straight full twist insert. The heat transfer coefficient increases with Reynolds number and decreasing with spacer distance with maximum being 2 in. spacer distance for both the type of twist inserts. Also, experiment show no appreciable increase in heat transfer enhancement in straight full twist insert with 2 inch spacer distance. Experiments were repeated in turbulent flow using straight full twist insert with 4 inch Spacer. Similar trend of increasing Nusselt number with Reynolds number was observed. Performance evaluation analysis shows that the maximum performance ratio was obtained for each twist insert corresponding to the value of Reynolds number of 2550.

Eiamsa-ard et al. experimental results on the mean 'Nu'; 'f' and 'g' in a round tube with short length TT insert shows that the presence of the tube with short length twisted tape insert yields higher heat transfer rate. The full length twisted tape is inserted into the tested tube at a single y = 4.0 while the short-length tapes mounted at the entry test section.

CONCLUSION

The construction, thermal characteristics, performance, and use of Twisted Tube type heat exchangers have been reviewed. It has been shown that this type of heat exchanger offers a number of advantages over the conventional shell and tube exchanger with segmental baffles. In suitable applications, Twisted Tube heat exchangers offers superior economic performance as defined by cost per unit heat load when compared to the alternative of conventional shell and tube type equipment. The conventional alternative has a somewhat lower shell side pressure loss than twisted tube, but both units are within the design specification. The conventional heat exchanger has a very poor hydraulic performance. This may be a result of a design error on the specific unit that is considered. Twisted tube has an advantage with respect to fouling and vibration issues.

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