International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 2 Issue: 2 202 – 207

Enhance the Performance of Heat Exchanger with Twisted Tape Insert: A Review

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Abstract—Enhancing heat transfer surface are used in many engineering applications such as heat exchanger, air conditioning, chemical reactor and refrigeration systems, hence many techniques have been investigated on enhancement of heat transfer rate and decrease the size and cost of the involving equipment especially in heat exchangers. One of the most important techniques used are passive heat transfer technique. These techniques when adopted in Heat exchanger proved that the overall thermal performance was improved significantly. This experimental works can be taken by researchers on Augmentation Technique such as Twisted Tape. So, Researchers tried to increase the effective surface area Contact with fluid to increases the heat transfer rate in the heat exchanger. We tried to enhance the Heat transfer rate with the help of Twisted Tape insert with Wiry Metallic Sponge and find out the effect of Metallic Wiry Sponge on Flow of Fluid.

Keywords —*Heat Exchanger, Tube, Twisted Tape, Swirl, Vortex, Augmentation.*

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1. INTRODUCTION

Heat Exchanger is a device in which the exchange of energy takes place between two fluids at different temperature. A heat exchanger utilizes the fact that, where ever there is a temperature difference, flow of energy occurs. So, That Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them. The energy flowing in a heat exchanger may be either sensible energy or latent heat of flowing fluids. The fluid which gives its energy is known as hot fluid. The fluid which receives energy is known as cold fluid. It is but obvious that, Temperature of hot fluid will decrease while the temperature of cold fluid will increase in heat exchanger. The purpose of heat exchanger is either to heat or cool the desired fluid.

In a special case, when one of fluid undergoes change in its phase, its temperature remains unchanged. These types of heat exchanger are known as condensers or evaporators. Heat exchangers with the convective heat transfer of fluid inside the tubes are frequently used in many engineering application. The techniques of heat transfer enhancement to accommodate high heat flux i.e., to reduce size and cost of heat exchangers have received serious attention passed years. Enhancement of heat transfer Rate in all types of thermo technical apparatus is of great significance for industry. Beside the savings of primary energy, it also leads to a reduction in size and weight. Up to the present, several heat transfer enhancement techniques have been developed. Twisted-tape is one of the most important members of enhancement techniques, which employed extensively in heat exchangers. [1]

1.1 Augmentation Techniques of Heat Transfer: Twisted Tape Insert

The augmentation techniques of heat transfer are widely applied to improving the performance of heat exchangers in chemical industries and air conditioning systems to reduce the size and costs of the heat exchangers, these techniques are classified as active and passive techniques. The active techniques require external forces, e.g. electric field, surface vibration or Jet impingement. The passive techniques require special surface geometries or swirl/vortex flow devices. Many of experimental works on heat transfer augmentation using twisted tape as swirl/vortex flow devices have been reported in the literature.

2. LITERATURE REVIEW

Anil Singh Yadav et al. insert the half length of twisted tape to Influence heat transfer and pressure drop characteristics in a U-bend double pipe heat exchanger have been studied experimentally. In the experiments, the swirling flow was introduced by using half-length twisted tape placed inside the inner test tube of the heat exchanger. In this work, the results obtained from the heat exchangers with twisted tape insert are compared with those without twisted tape. The experimental results revealed that the increase in heat transfer rate of the twisted-tape inserts is found to be strongly influenced by tape-induced swirl or vortex motion. The heat transfer coefficient is found to

increase by 40% with half-length twisted tape inserts when compared with plain heat exchanger. It was found that on the basis of equal mass flow rate, the heat transfer performance of half-length twisted tape is better than plain heat exchanger, and on the basis of unit pressure drop the heat transfer performance of smooth tube is better than half-length twisted tape. It is also observed that the thermal performance of Plain heat exchanger is better than half length twisted tape by 1.3-1.5 times.

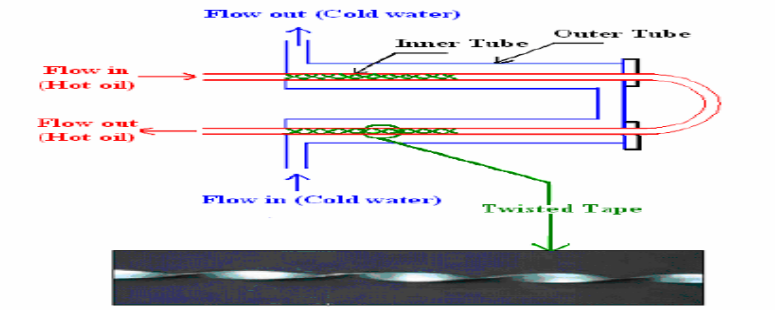

Fig. 1 Inner Tube Fitted with Half Length Twisted Tape. [1]

S.D.Patil et al. refers different methods of Heat transfer augmentation techniques used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques broadly are of three types viz. passive, active and compound techniques. In this review they work on the passive augmentation techniques used in the recent past. From this review they found that twisted tape insert mixes the bulk flow well and therefore performs better in laminar flow. Because of laminar flow Thermal resistant was not limited to a thin region. The result also shows twisted tape insert is more effective, if no pressure drop penalty is considered. They also concluded that twisted tape insert is not effective in turbulent flow, because it blocks the flow and therefore pressure drop increases. Hence the thermo hydraulic performance of a twisted tape is not good in turbulent flow. [2]

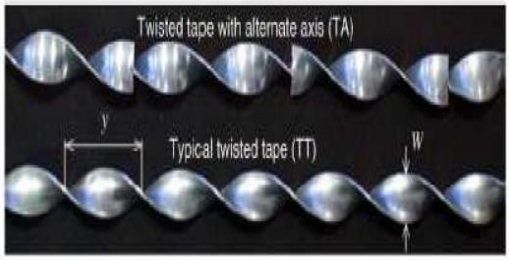

Fig.2 The Twisted tapes used in the Test Tube [2]

Watcharin Noothong et al. Influences of the twisted tape insertion on heat transfer and flow friction characteristics in a concentric double pipe heat exchanger have been studied experimentally. In the experiments, the swirling flow was introduced by using twisted tape placed inside the inner test tube of the heat exchanger with different twist ratios, y = 5.0 and 7.0. The experimental results revealed that the increase in heat transfer rate of the twisted-tape inserts is found to be strongly influenced by tape-induced swirl or vortex motion. Over the range investigated, the maximum Nusselt numbers for using the enhancement devices with y = 5.0 and 7.0 are 188% and159%, respectively, higher than that for the plain tube. In addition, the effects of the twisted tape on the heat transfer enhancement efficiency are also investigated. [3]

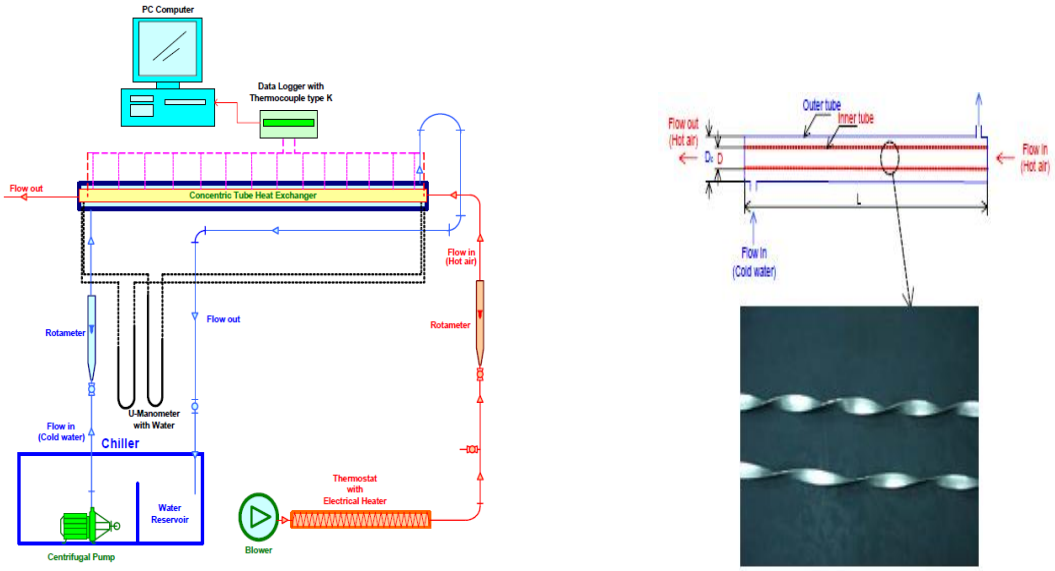

Fig. 3 a) Experimental apparatus b) The inner tube fitted with twisted tape [3]

Bodius Salam et al. Work on Heat Transfer Improvement in Tube with Twisted Tape Insert. An Experimental investigation was carried for measuring tube side heat transfer coefficient of water for turbulent flow in a circular tube fitted with twisted tape insert. A stainless steel twisted tape insert of 5.3 twist ratio was inserted into the smooth tube. A uniform heat flux condition was maintained by wrapping Nichrome wire around the test section and fibre glass over the wire. Outer surface temperatures of the tube were measured at 5 different points of the test section by T-type thermocouples. At the outlet section the thermometer was placed in a mixing chamber. The Reynolds numbers were varied in the range 9500-20000 with heat flux variation 9 to 18 kW/m^2 for smooth tube, and 15 to 31kW/m^2 for tube with insert. Nusselt numbers obtained from smooth tube were compared with Dittus and Boelter correlation and error were found to be in the range of -13% to 18% with r.m.s. value of 12%. At comparable Reynolds number, Nusselt number in tube with twisted tape insert was enhanced by 2.9 to 4 times compared to that of smooth tube. [4]

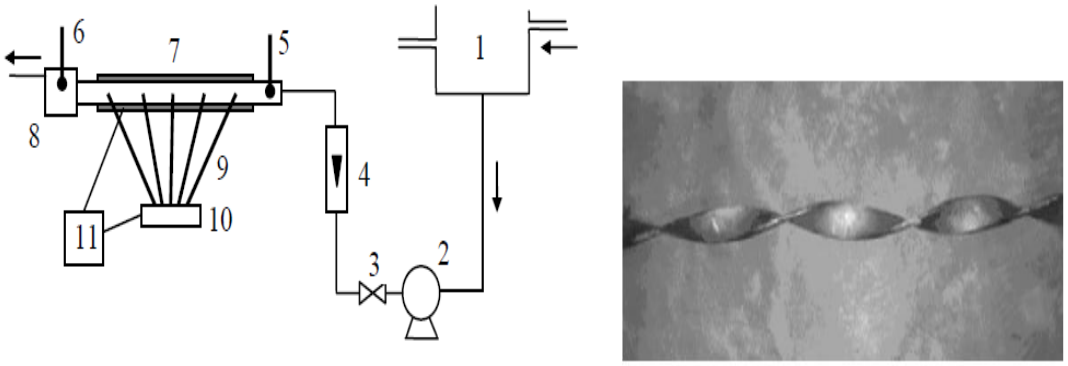

Fig. 4 Schematic Diagram of Experimental Apparatus & Twisted Tape [4]

J. U. Ahamed et al. Work on Heat transfer performance of porous twisted tape insert in a circular tube was experimentally investigated. Tube wall temperatures and pressure drops along the axial distance of the test section at steady state condition were measured for different flows having Reynolds number ranging from 1.4 x 104 to 5.2 x 104 for both the plain and the tube with porous twisted tape insert. Heat transfer coefficient, friction factor, and pumping power were calculated from the measured data. Heat transfer and fluid flow characteristics of the porous twisted tape inserted tube were explained from the measured and calculated values. Performance of the porous twisted tape inserted tube was also evaluated. The results showed for porous twisted tape inserted tube, the average heat transfer coefficient was 2.60 times higher, the heat flux was 1.55 times higher, the friction factor was 2.25 times higher and the pumping power was 2.0 times higher than those of plain tube values for similar flow conditions. [5]

Fig. 5 Photograph of the experimental facility [5]

Prof. Naresh B. Dhamane et al. Work on Heat Transfer Analysis of Helical Strip Insert with Regularly Spaced Cut Sections Placed Inside a Circular Pipe. This paper presents an experimental study of heat transfer and friction characteristics in turbulent flow generated by a helical strip inserts with regularly spaced cut passages, placed inside a circular pipe across the test section. The experiments were conducted for water flow rates in the range of Re 5000 to Re 30000. For the experiment three different types of helical strips with helix angles of 30◦, 45◦ and 60◦ were used. Experimental results show that, the use of a helical strip inserted inside a circular tube results into an enhancement of heat transfer rate as they cause the turbulence in the flow with swirling moment. The local heat transfer coefficients were found to be increasing to very high values along the downstream of the helical strip, and then decreasing with the distance. The increase of heat transfer was found to be dependent on the Reynolds number in typical case. The effect of the number of the helical channels, and helix angle, on heat transfer was minute. They found that using the helical tape can help to increase the heat transfer rate up to 20% depending on Re at constant pumping power. Enhancement efficiency decreases with increasing Reynolds number. [6]

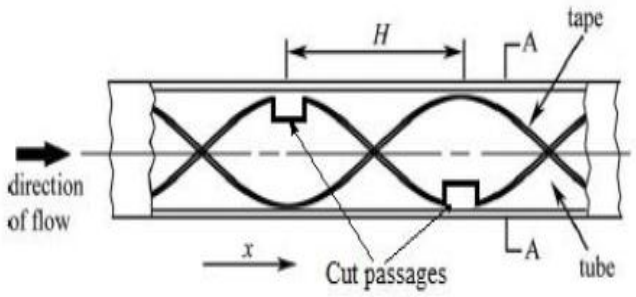

Fig.6 Construction of helical strip with regularly cut passages [6]

Sami D. Salman et al. Work on CFD analysis of Heat transfer and friction factor Characteristics in a circular tube fitted with Parabolic-cut twisted tape inserts. The Computational Fluid Dynamics (CFD) modelling study on heat transfer and friction factor of a constant heat-fluxed tube equipped with Parabolic-cut twisted tape inserts in the laminar flow regime using a commercial CFD package (FLUENT-6.3.26). In this study two geometry parameters of the Parabolic-cut twisted tape have been considered, a twist ratio and cut depth. The simulation has been carried out for twist tapes with twist ratio (y=2.93, 3.91and 4.89) and cut depth (w =0.5, 1 and 1.5 cm). The CFD predicted results matched with the literature correlations for plain tube for validation; with the discrepancy of less than ±8%for Nusselt number and ±6.5 % for friction factor. The results have also revealed that the Nusselt number and the friction factor in the tube with Parabolic-cut twisted tape (PCT) increase with decreasing twist ratios (y) and cut depth (w). [7]

Fig. 7: Parabolic-cut twisted insert [7]

Gaurav Johar et al. Modified twisted tape inserts as Passive Heat transfer augmentation device. Effect of Reduced width twisted tape (RWTT), Baffled Reduced width twisted tape (BRWTT1) & Baffled Reduced width twisted tape with holes (BRWTT2) on heat transfer and friction factor for heating of water for Reynolds number range 2500-30000, was studied experimentally in a double pipe heat exchanger. Three tapes of different twist ratio (yw=3.69, yw=4.39, yw=5.25) for RWTT, BRWTT1 & BRWTT2 were used. Based on constant flow rate, the heat transfer coefficient were found to be 1.18-3.66, 2.61-7.07 & 3.58-8.08 times the smooth tube values for RWTT, BRWTT1 & BRWTT2 respectively. The friction factor values were found to be 3.23-5.96, 7.79-11.23 & 8.86-14.44 times the smooth tube values for RWTT, BRWTT1 & BRWTT2 respectively. Based on constant pumping power, the heat transfer coefficient values were found to be 0.88-1.62, 1.59-3.70 & 2.12-4.49 times the smooth tube values for RWTT, BRWTT1 & BRWTT2 respectively. Based on Increase in Heat transfer coefficient, Performance evaluation criteria R1 & R3, it was concluded that Baffled Reduced width twisted tape & Baffled Reduced width twisted tape with holes performs much better than Reduced width twisted tapes(RWTT) of the same twist ratio. [8]

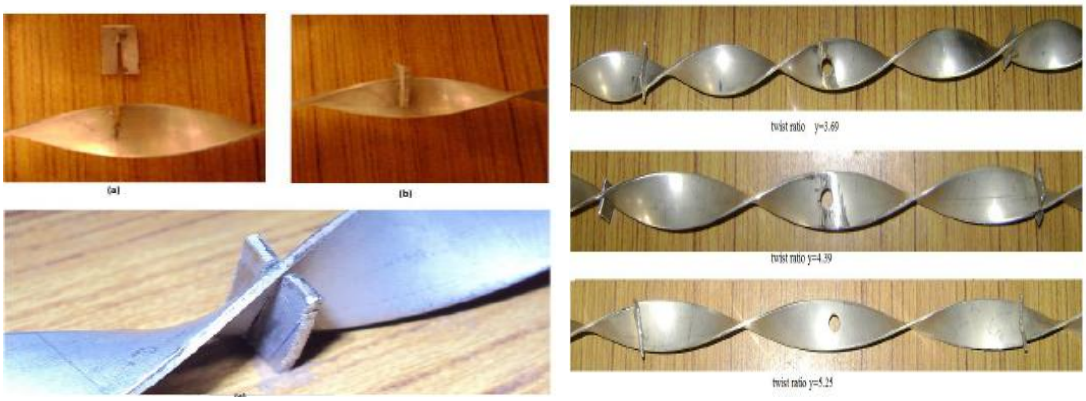

Fig 8 Baffled Reduced Width Twisted Tape with holes [8]
a) BRWTT1 b) BRWTT2)

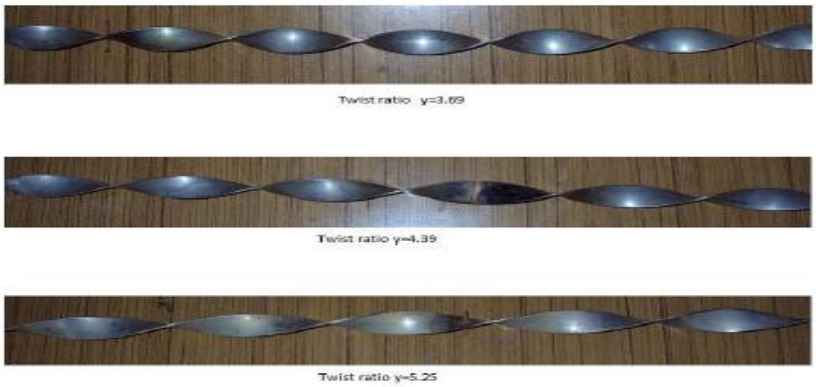

Fig 9 Reduced Width Twisted Tape (RWTT) [8]

3. Future Scope and Conclusion

From this Review work we conclude that Heat Transfer Rate Will Increases with Increase contact Surface Area of Twisted Tape insert in the Tube with Fluid. When Researchers Increases the Contact Surface Area of Twisted Tape with making a Cut, Drill Hole, Parabolic cutting, and many more etc, than Heat transfer Rate in Heat Exchanger will be increases.

- If we insert Twisted Tape with Metallic wiry Sponge than it will helpful to increase the Rate of Heat Transfer in Tube.
- Twisted Tape with Spiral Section, Spiral Section has large surface and good contact Area with fluid. So, it will Increases the heat Transfer Rate.

4. References

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