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DESIGN MODIFICATION IN HEAT EXCHANGER TWISTED TAPE FOR HEAT TRANSFER ENHANCEMENT- A REVIEW

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ABSTRACT

Heat exchangers are very much essential industrial as well as domestic equipment used every day. Overall performance of any machine and many systems as a whole depends on the performance of a heat exchanger. To improve the performance of a heat exchanger it is needed to improve the heat transfer phenomena of a tube. Number of researches has been done to develop devices or means to enhance the performance of a heat exchanger. The most successful development of a component for the most efficient enhancement of heat exchanger performance is development of twisted tape inserts for heat exchanger tubes. It increases flow path of the fluid inside the tube so that more and more and more heat can be transferred from the tube. At the same time due to this twisted tape insert turbulence of the flow inside the tube can be increased. This increase in turbulence will in other way decrease the overall efficiency of the heat exchanger. So optimum design of tube insert is very essential for having maximum efficiency.

Keywords - Tube insert, Twisted tape, Reynolds's number, Nusselt Number.

I. INTRODUCTION

Heat exchanger is a device that facilitates the exchange of heat between two fluids that are at different temperatures. Heat exchangers are used for both the purpose to remove heat from a fluid and to provide heat to a fluid. Common examples of heat exchanger are boiler, condenser, super heater, economizer, automobile radiators. Heat exchangers are commonly used in practice in a wide range of applications, from heating and air conditioning systems in a household, to chemical processing and power production in large plants.

To predict the performance of a heat exchanger, it has to be relate to the governing parameters for example heat transfer area, overall heat transfer coefficient, mean temperature difference. Assume that there is no heat transfer to the surrounding and negligible kinetic and potential energy then by energy balance we can find a relation.

Heat exchanger performance can be enhanced by different ways such as considering the initially heat exchanger is operating correctly, consider increase in pressure drop if available in heat exchanger with single phase heat transfer, heat transfer coefficient can be improved with increased velocity, consider fouling factor, for certain condition consider enhanced heat transfer through the use of finned tubes, inserts, twisted tubes or modified baffles [15].

Various types of techniques are used for the heat transfer process, which is generally referred to as heat transfer enhancement, and extensive reviews of these methods and their applications. These techniques are classified as active or passive techniques. No external energy input required in Passive techniques, except for pump or blower power to move the fluid, and involve the use of roughened surfaces, extended surfaces, displaced promoters, and swirl flow devices, among some others. In Active enhancement techniques, external power is required to affect the process to get better heat transfer. Therefore, passive techniques are preferred and they have seen wider applications.

Among various enhancement techniques that can be used, swirl flow generation by using full-length twisted-tape inserts is found to be extremely effective [1], [3], [4].Significant increase in heat transfer can be obtained,

particularly in laminar flows. Other methods that promote swirl flows include curved ducts, tangential fluid injection, and twisted or convoluted ducts. Their thermal-hydraulic characteristics, heat transfer improvement potential, and typical applications have been outlined

It is commonly known fact that heat transfer is considerably improved if the flow is stirred and mixed well. This is the basic principle in development of enhancement techniques that generate swirl flows. Twisted tape insert mixes the bulk flow well therefore heat transfer increases [12]. Twisted tape inserts may be the most convenient and effective techniques among them that promotes secondary flow. They are comparatively simple to construct and fit in the tubes of shell-and-tube or tube-fin type heat exchangers.
Heat transfer enhancement may occur for three reasons:

1. The tape reduces the hydraulic diameter, which affects an increased heat transfer coefficient, even from zero tape twist.
2. A tangential velocity component is occurred due to the twist in tape. Hence, the speed of the flow is amplified near the wall. The improvement in heat transfer is a consequence of increased shear stress at the wall. Also heat transfer is improved by mixing fluid from the core region (cold) with fluid in the wall region (hot).
3. There may be heat transfer from the tape.

The convective heat transfer is enhanced significantly by the consequent well mixed helical swirl flow [13]. Mostly its depends how the tape fits compactly at the tube wall and what material it is made of, there may be some tape-fin effects as well. The improved heat transfer because of twisted-tape inserts, is also accompanied by a rise in pressure drop and suitable trade-offs must be considered by designers to optimize their thermal-hydraulic performance.

II. REVIEW OF PREVIOUS WORKS

An experimental study has been conducted by A. E. Bergles and S. W. Hong [2] to investigate heat transfer augmentation by means of twisted-tape inserts in laminar flow. The investigation focused on fully-developed laminar flow heat transfer and pressure drop in horizontal tubes with uniform axial heat flux. The heat transfer results indicate that the Nusselt number is a function of tape twist ratio, Reynolds number, and Prandtl number. Nusselt numbers greater than 40 were obtained. The recommended heat transfer correlation is given in following equation

$$Nu_s = 5.172\,[1 + 5.484 * 10^{-3} Pr^{0.7} (Re_s/y)^{1.25}]^{0.5}$$

J. P. Du Plessis, D. G. Krogers [3] did a very important research on nature of flow over twisted tape. They considered the flow as laminar and developed a correlation between friction factor and flow parameters like Reynolds number. The relation they have derived is

$$f_D = f_D(\varepsilon)[1 + \left(\frac{Re_D}{y^{1.3}}\right)^{1.5}]^{1/3}$$

J. P. Du Plessis and D. G. Kroger [4] have developed a correlation of heat transfer for the case of thermally developing laminar flow in a smooth tube with a twisted-tape insert in a heat exchanger tube. The correlation given is

$$Nu_{m,D} = 1.58\Psi_\varepsilon[1 + 0.153(x_\infty^*)^{-1.05}]^{1/3} \times [1 + 0.000064(\Omega_\varepsilon Pr)^3]^{0.117} \times [1 + 0.002\Omega_\varepsilon^{1.4}]^{1/7}$$

R. M. Manglik, A. E. Bergles [5] have developed correlations for friction factor and Nu_m based on experimental data for water and ethylene glycol, with tape inserts of three different twist ratios in laminar flow. They found that heat transfer augmented due to more flow time of fluid in the tube as longer flow path and secondary fluid circulation.

A Dewan, P Mahanta, K Sumithra Raju, P Suresh Kumar [6] have reviewed the different heat transfer rise techniques to implement it in heat exchanger. They mentioned that thermo hydraulic behaviour of an insert mainly depends on the flow conditions (laminar or turbulent) apart from the insert configurations.

Sivashanmugam and Suresh [7] and Selvakumar and Suresh [8] did experimental work on the turbulence nature of fluid flow over a twisted tape with different geometrical configuration of a twisted tape. They also investigated the investigated heat transfer phenomenon and friction factor of the swirl flow.

P. Murugesan, K. Mayilsamy, S. Suresh [10] have experimentally investigated effect of U cut on heat transfer and friction factor in a tube twisted tape insert. They found that Nusselt number in the tube with U cut twisted tape (UTT) is higher than those in the plain tube and tube with plain twisted tape (PTT) insert over the range of Reynolds number 2000-12000.

S. S. Joshi, V. M. Kriplani [11] experimentally investigated the effect of annular inserts and tape inserts on the performance of concentric tube heat exchanger. They analyzed effectiveness of heat exchanger and also friction factor for both inner and annular flow. The heat transfer in the heat exchanger enhanced by using inserts and Tapes and use of annular insert causes slight increase in heat transfer coefficient and effectiveness of heat exchanger.

A. M. Patil, S. D. Patil [12] has used double pipe heat exchanger and twisted tape of different twist ratio. Twisted tape is inserted in inner tube of double pipe heat exchanger. Effect of inserts on effectiveness of heat exchanger is analyzed for different Reynolds Numbers.

C. Nithiyesh Kumar, P. Murugesan [13] has review the enhancement of heat transfer by using twisted tape insert. They found that twisted tape and modified twisted tape inserts mixes the bulk flow well and therefore performs better in laminar flow. 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. It is observed that modified twisted tape geometry, the heat transfer rate is higher with reasonable friction factor for both laminar and turbulent flow.

Veeresh Fuskele, Dr. R. M. Sarviya [15] did work experimentally which includes determination of friction factor and heat transfer coefficient for twisted wire mesh having twist ratio 5 and 7. The result of experiment that the heat transfer coefficient varied from 2.09 to 1.69 times and friction factor increased 4.3 to 4 times the smooth tube value. Twisted wire mesh posses the porous nature due to that it provides comparatively more ease in flow as lesser frictional surface and less friction factor in comparison to conventional twisted tape.

A very recent work has been done by Rupesh J Yadav, Atul S. Padalkar [17] in the year of 2013 on the characteristics of flow through a heat exchanger tube with twisted tape insert. The authors have considered four combinations of twisted tape insert, half-length upstream twisted tape condition, half-length downstream twisted tape insert, full-length twisted tape, inlet twisted tape and plain tube. It has been observed that thermal performance and local peak in heat transfer could be increased by using a combination of inserts with different geometries in the plain tubes while reducing the pressure drop. While, the characteristic of local peaks observed in the investigation can be used in avoiding the local hot spots in heat exchanger application.

Dr. A. G. Matani, Swapnil A. Dahake[18] experimentally determined effect of twisted tapes and wire coil on pressure drop, friction factor , heat transfer and thermal enhancement index.

A. Rahul Kumar, P. N. S. Srinivas [19] in 2013 investigated the swirl flow behavior and the laminar convective heat transfer in a circular tube with twisted-tape inserts.

Kevin M. Lunsford [20] has given methods for increasing shell-and-tube exchanger performance. The methods consider whether the exchanger is performing correctly to begin with, excess pressure drop capacity in existing exchangers, the re-evaluation of fouling factors and their effect on exchanger calculations, and the use of augmented surfaces and enhanced heat transfer. Three examples are provided to show how commercial process simulation programs and shell-and-tube exchanger rating programs may be used to evaluate these exchanger performance issues.

III. CONCLUSION

From the review of literatures it is observed that the heat transfer phenomenon enhanced by means of finned tubes, inserts, twisted tubes or modified baffles etc. To get better efficiency of industrial system as well as domestic equipments it is required that the effectiveness of heat exchanger to be maximum. And the performance of heat exchanger is related to the governing parameters such as heat transfer area, overall heat transfer coefficient, mean temperature difference. Among various techniques the most successful development of a component for efficient

enhancement of heat exchanger is development of twisted inserts for heat exchanger tubes. And the objective of study is to modification of twisted tape inserts for better performance of heat exchanger.

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