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*Research Article*

# Heat Transfer Analysis on Twisted Tube Heat Exchanger Technology

(A Latest trend in Heat Exchanger Technology)

**P.Eswar Raja Babu**

B.Tech, Chemical Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India

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***Abstract***

*Majority of all heat exchanger applications in field of pharmaceutical industries, dairy , petrochemical ,oil refining, crude oil units power generation plants employ the use of conventional shell -tube type and plate type heat exchangers. It is estimated and observed that shell and tube technology is a cost effective, proven solution for a wide variety of heat transfer requirements. However, there are limitations with this technology. Factors such as inefficient usage of shell side, pressure drop, and dead or low flow zones around the baffles where fouling and corrosion can occur, and tube vibration etc may eventually result in equipment failure. This paper presents a recent innovation and development of a latest heat exchanger technology, known as Twisted Tube technology, which has been able to overcome the limitations of the conventional technology, this technology provides solution to almost all mentioned problems and provide good overall heat transfer coefficients through tube side enhancement. This paper primarily focuses on thermal analysis on twisted tube Heat exchangers*

***Keywords:*** *Twisted tube heat exchanger, Thermal boundary layers, Reynolds Number, Overall film heat transfer coefficient, Number of transfer units, Logarithmic mean temperature difference, vortex stability, effectiveness,* Heat transfer Regimes

## 1. Introduction

Heat Exchangers, one of the common equipment used for heating process fluids either by direct or indirect means. However the efficiency of the existing heat exchangers is poor and no longer high when used for longer time. In order to enhance the rate of heat transfer and efficiency twisted tube heat exchangers play a vital role. Heat exchangers are generally characterized by the compactness factor in m2/m3 (=/m) and it is generally accepted that values greater than 700/m characterize the compactness of the equipment. Although shell and tube heat exchangers can have a compactness factor, compact heat exchangers are often referred as non tubular devices.

This paper describes an advance shell and tube heat exchanger with twisted tube which always enhances surface area provided due to twisting and corrugations. Recent advances in the range of design and operational reliability and flexibility have made twisted tube heat exchangers attractive in various industries, including offshore applications, pharma, dairy industries and in the field of petroleum processing industries. Taking into the size and surface area of contact, these heat exchangers can be cost effective in a wider range of applications than the traditional type of heat exchangers employed in process industries.

*Corresponding author: **P.Eswar Raja Babu**

## 2. Twisted Tube Heat Exchanger

Heat transfer rate enhancement is one of the fast growing areas of Heat transfer technology .In fact techniques are available for the improvement of various modes of heat transfer. Second and third generation enhancement technology is already in use in process industry. Coming to the Heat exchanger technology twist type heat exchangers, corrugated surface heat exchangers and extended surface heat exchangers have greater advantages when compared with conventional type of heaters.

A twisted tube is a passive heat transfer enhancement device, generally classified in a swirl type flow device category. Swirl flow devices consist of a greater variety of geometrical flow arrangements in order to produce a stable form of forced vortex fluid motion in confined flows. This device facilitates fluid agitation and mixing of heat patterns induced by swirl flow. The main advantages are mainly they do not require extra attention during assembly, maintenance, inspection and cleaning when intermediate viscous fluids are used.

This devices consists of helically twisted double radius oval tubes, welded their round ends to tube sheets. This device design is similar to structure of Human DNA which is double helical in patterns and extended all along the length and finally ends with DNA strands. The tubes contact one another at their wider sides, six times over the length of one twist pitch which makes the unit practically vibration free. The purely longitudinal shell side flow in twisted tube bundles thereby has an ability to provide high surface area (and density), low pressure drop, good heat transfer rates and coefficients.

## 3. Materials

These devices involving the tubes can be fabricated by a variety of materials like carbon steel, stainless steels, monal metal , brass, nickel and corresponding alloys that has good heat transfer characteristics etc.

## 4. Flow Patterns and Flow Regimes in Twisted Tube Heat Exchangers

It is commonly thought the low Reynolds number flow regimes are typically of compact heat exchangers such as plate exchangers and that high Reynolds numbers usually occur in Shell and tube heat exchangers .For lower Reynolds numbers typical enhancement method seek to reduce the critical Reynolds number that separates laminar from transitional flow. In swirl flow this is accomplished by a developed secondary flow and by stimulating the growth of boundary layer instabilities. The superimposed swirl flow will produce a higher heat transfer rates but includes a pressure drop penalty .For the transition from the laminar to turbulent regime ,the heat transfer enhancement is higher than the pressure drop increase, Enhancement for higher Reynolds number is difficult because turbulent eddies become more and more vigorous with increasing Reynolds number

## 5. Heat Transfer Characteristics

When discussing the heat transfer under different conditions, in most of the cases it is very difficult to make direct and correct comparison using the inlet and outlet temperature and pressure drop. Generally, the compared systems are so differently conceived that the calculated heat transfer coefficients sever only as a guideline .Only in rare cases when the two compared units are identical in construction, can the heat transfer coefficient be used as a measure for direct comparison. In comparing twisted tube to conventional baffled heat exchangers, it should be noted that the compactness of twisted tube bundles leads to high performance. Thus a twisted tube heat exchanger tube bundles tends to have higher heat transfer coefficients .This leads to higher overall performance despite the adverse effect smaller hydraulic radius has on the frictional pressure drop.

## 6. Factors Contributing to Performance of the Heat Exchangers

*Number of heat transfer units*

The Number of Transfer unit method is used to calculate the rate of heat transfer (especially counter current exchangers) when there is insufficient information to calculate the Logarithmic means temperature difference (LMTD). In heat exchanger analysis, if the fluid inlet and outlet temperatures are specified or can be determined by simple energy balance, the LMTD method can be used; but when these temperatures are not available The NTU or The Effectiveness method is used.

$$E = \frac{NTU}{1+NTU},$$
$$E = 1-\exp[-NTU]$$

Where E is Effectiveness, It is the ratio between the actual heat transfer rate and the maximum possible heat transfer rate. E=q/q(max) . q(max) is maximum rate of heat transfer.

*Mean Temperature Difference*

The temperature of the cold fluid and hot fluid keeps on changing from the inlet to outlet all along the length of the heat exchanger .In order to observe the heat transfer rates and to calculate efficiency of the equipment it is necessary to take a mean temperature. However it is not preferable to take average or geometric mean or some other approximation because the chances of error and accuracy in evaluating the data is quite poor with large amount of errors .Thus logarithmic mean facilitates to evaluate mean temperature with small error and this temperature is known as Logarithmic mean temperature difference often known as LMTD

$$LMTD = \frac{\Delta T_A - \Delta T_B}{\ln\left(\frac{\Delta T_A}{\Delta T_B}\right)} = \frac{\Delta T_A - \Delta T_B}{\ln \Delta T_A - \ln \Delta T_B}$$

*Overall Film Heat Transfer Coefficient*

In order to account for heat transfer coefficients inside and on outside surface of the tube with respect to fouling phenomenon it is mandatory to take a net and overall value of heat transfer rate, which is known as Overall Film Heat transfer Coefficient

## Conclusions

It is ultimately apparent that the development of rationally optimized heat exchanger design with superior surface characteristics could be achieved only if the basic phenomenon are well known and understood. Inspite of considerable activity , the field of enhanced heat transfer is not the old and casual. In fact it is anything but ordinary. Experimentation is difficult, modeling of the phenomenon is not that easy and it involves tedious work and calculations with sophisticated analytical and numerical techniques are required to get the results that exactly fit the model of the equipment and give satisfactory results.

However this technology is more expensive than a conventional shell and tube, plate type heat exchangers, but their payback time is quite less. Taking the factors such as high heat transfer coefficients, high Reynolds ,Nusselts and Prandtle numbers, good flow characteristics and conditions favoring the rates of heat transfer it finds a unique position in the filed process engineering and all chemical engineering applications.

For evaluating heat exchangers under the same operating conditions, the heat transfer coefficient is normally assumed as a basic measure of efficiency and then factors as pressure drop, cost and maintenance are considered. From the relationship between the physical laws which are usually obtained by dimensional analysis ,which is often explained as the methodology of correlating different physical parameters in terms of the other which cannot be directly measured by means of experiment al evaluation.

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