# A Comparative Experimental Studies on Effect of Twisted Tape Insert on Performance of Plane Steel Tube and Plane Copper Tube DPHE

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*Abstract*— Work presents the effects of twisted tape inserts of different materials and different twist ratio on the performance of concentric double pipe heat exchanger by using air and water as working medium. The twisted tape inserts when placed in the path of the flow of the fluid, create a high degree of turbulence resulting in an increase in the heat transfer rate of heat exchanger with the twisted-tape inserts is found to be strongly influenced by tape-induced swirl or vortex motion. The conversion utilization and recovery of energy in every industrial commercial and domestic application involve a heat exchanger process some common example are stream generation and condensation in power and co-generation plant ,sensible heating and cooling on viscous media in thermal processing of chemical, and agriculture products refrigerant evaporation and condensation in air conditioning and refrigeration gas flow heating in manufacturing and waste heat recovery air and liquid cooling of engine of electrical machine and electronic device improve heat exchange, over and above the usual of standard practice can significantly improve the thermal efficiency in such application as well as the economically of their design and operation. Double pipe heat exchanger (DPHE) is the simplest application of heat exchanger. This kind of heat exchanger is widely used in chemical, food and oil gas industries. Double pipe heat exchanger is having a relatively small diameter and it is easy to fabrication a compare a helical tube and straight tube and many more compact tube of heat exchanger. Commonly method used to by the reaches to enhance the heat flow rate is active method, passive method and present work is based on passive method. In the present work experiment this carried out on double pipe heat exchanger in which hot water is flowing through in a tube where a cold water is flowing through the annular and hot water to water heat exchanger is taken in consideration. During the experiment cold water flow rate is constant at 45 LPH, where the hot water flow rate on various from 15 LPH to 75 LPH. In this experiments we have used the twisted tap insert with 2.5 inch pitch with copper tube and plain steel tube and plain copper tube without insert in parallel and counter flow arrangement and then comparatively study on their performance.

***Key words:*** Concentric Tube, Heat Transfer, Twisted Tape with Copper and Aluminium and Friction Factor

## I. Introduction

Heat transfer enhancement or augmentation techniques refer to the improvement of thermo hydraulic performance of heat exchangers .Among many techniques (both passive and active) investigated for augmentation of heat transfer rates inside circular tubes, a wide range of inserts have been utilized, particularly when turbulent flow is considered. A lot of methods are applied to increase thermal performance of heat transfer devices such as treated surfaces, rough surfaces, swirling flow devices, coiled tubes, and surface tension devices. Furthermore, as a heat exchanger becomes older, the resistance to heat transfer increases owing to fouling or scaling. These problems are more common for heat exchangers used in marine applications and in chemical industries. In some specific applications, such as heat exchangers dealing with fluids of low thermal conductivity (gases and oils) and desalination plants, there is a need to increase the heat transfer rate. The heat transfer rate can be improved by introducing a disturbance in the fluid flow (breaking the viscous and thermal boundary layers), but in the process pumping power may increase significantly and ultimately the pumping cost becomes high. Therefore, to achieve a desired heat transfer rate in an existing heat exchanger at an economic pumping power, several techniques have been proposed in recent years and are discussed in the following sections.

### A. *Heat Transfer Enhancement*

Working for the goal of saving energies and to make compact the design for mechanical and chemical devices and plants, the enhancement of heat transfer is one of the key factors in design of heat exchangers. Heat transfer enhancement techniques are generally categorized in two types.

### B. *Heat Transfer Enhancement Method*

Geometry heat transfer coefficient (overall heat transfer coefficient) depends on different parameters like orientation of heat exchanger, geometry of heat exchanger, properties of fluid flow, type of fluid like laminar and turbulent, material of tube etc.

As it is seen that heat transfer in case of turbulent flow is always greater than the transfer of heat in laminar flow. Heat transfer rate can be increased by producing turbulence effect in fluid flow. Turbulence can be created by two ways.

### C. *Active Methods*

These techniques are more complex in use and design point of view as these methods require some external power input to cause the desired flow amendment and progress in rate of heat transfer. It has limited application because of the require of external power in many practical applications. In comparison with passive techniques, this technique has not shown much potential as it is difficult to give external power input in lots of cases.

In these cases, external power is use to assist the desired flow amendment and the associated improvement in the rate of heat transfer.

1) *For Example*

- Mechanical aids
- Surface vibrations
- Water vibration
- Electrostatic fields (DC or AC)

- Jet impingement
- Suction.
- Jet impingement.

1) Mechanical Aids

It stirs the fluid by mechanical means or by rotating the surface. Surface "scraping" generally use for batch processing of viscous liquids in the chemical process industry, is applied to flow of such different water as high viscosity, plastics and air. Equipment with rotating heat exchanger ducts is found in commercial practice.

2) Surface vibration

These are either low or high frequency has been used primarily to improve single-phase heat transfer. Surface vibration is the most practical type of vibration enhancement, given the mass of most heat exchangers. The vibration ranges from pulsations of about 1 HZ to ultrasound. Single phase fluid is of primary concern.

3) Fluid vibration

These are mainly use in single phase flow and are considered to be possibly the most practical type of vibration enhancement technique.

4) Electrostatic fields

These are applied in various ways to dielectric water. Commonly, electrostatic fields can be directed to cause bulk mixing of water in the vicinity of the heat transfer surface, which enhances heat transfer .An electrical field and a magnetic field may be combined to provide a forced convection or electromagnetic pumping.

5) Injection

It involves supplying gas to a flowing liquid through a porous heat transfer surface or injecting alike fluid up stream to heat transfer section. Surface degassing of liquids can make enhancement alike to gas injection. Only single phase flow is of common interest.

6) Suction

It involves either vapours for removal through a porous heated surface in nucleate or film boiling, or fluid withdrawal throughout a porous heated surface in single phase flow. Two or more of these techniques may be used simultaneously to produce an enhancement larger than that produced by only single technique. This simultaneous use is termed as compound enhancement. It should be emphasized that one reason for studying enhanced heat transfer is to assess the effect of an inherent condition on heat transfer. degassing of liquids with high gas content, surface vibration resulting from rotating machinery or flow oscillations, fluid vibration resulting from pumping pulsation, and electric fields present in electrical equipment.

7) Jet impingement

It involves the direction of heating or cooling fluid perpendicularly or obliquely to the heat transfer surface.

### *D. Passive Methods*

These techniques commonly use surface or geometrical changes to the flow channel by incorporating inserts or additional devices. They endorse higher heat transfer coefficients by disturbing or changing the existing flow nature (except for extended surfaces), which also tends to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately tends to increase in water pressure drop. They normally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They endorse higher heat transfer coefficients by disturbing or change the existing flow nature except for extended surface.

*1) For example*

Passive method does not require any external power for enhancement of heat transfer rate. By modifying the geometry of exchangers, by modifying the surface finish or by modifying the flow by inserting or additional devices the heat transfer rate of heat exchangers can be enhanced.

- Treated surfaces
- Rough surfaces
- Extended surfaces
- Displaced enhancement devices.
- Swirl flow devices
- Coiled tubes
- Additives for gases
- Additives for liquids.

Enhancement techniques can be categorised as passive methods, which require no direct application of external power, or as active schemes, which require external power. The effectiveness of both types depends mainly on mode of heat transfer, which might range from single-phase free convection to dispersed-flow film boiling. Brief descriptions of passive techniques follow.

1) Treated Surfaces

Treated surface involve fine scale alter of the surface finish or coating (continuous or discontinuous).They use for boiling and condensing; the roughness height is below, which affects single-phase heat transfer.

2) Rough Surfaces

These are produced in many configurations, ranging from random sand-grain type roughness to discrete protuberances. The configuration is generally chosen to promote turbulence rather than to increase the heat transfer area. The application of rough surface is directed primarily towards single phase flow.

3) Extended Surfaces

These are routinely employed in many heat exchangers. The development of non-conventional extended surfaces, such as integral inner fin tubing, and progress of heat transfer coefficients on extended surfaces by shaping or interrupting the surfaces are of particular interest.

4) Displaced Enhancement

These devices are inserted in the flow channel so as to indirectly improve energy transport at the heated surface. They are use with forced flow.

5) Swirl Flow

These devices include a number of geometric arrangements or tube inserts, for forced flow that create rotating and/or secondary flow. Inlet vortex generators, twisted-tape inserts, and axial-core inserts with a screw-type winding.

6) Coiled Tubes

It leads to compact heat exchangers. The secondary flow leads to higher single-phase coefficient and progress in most regions of boiling. Surface tension devices comprises of wicking or grooved surfaces to direct the flow of liquid in boiling and condensing.

7) Additives Liquids

It includes solid particles and gas bubbles in single-phase flows and liquid trace additives for boiling system.

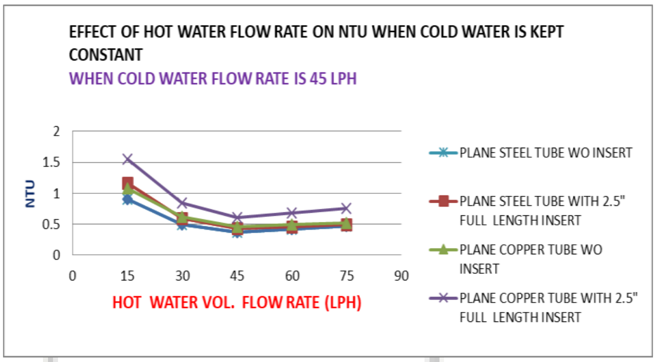
8) Additives for gases

These liquid droplets or solid particles, either dilute phase (gas-solid suspension) or dense phase (water sized beds). The active techniques are now described.

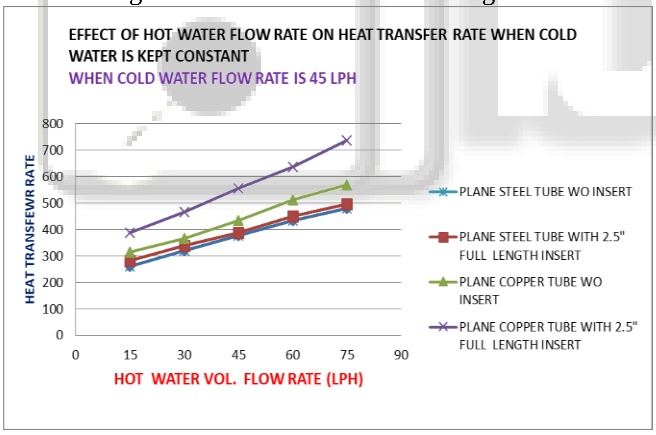
*2) Compound Method*

It is a combination of both active and passive methods.

## II. GRAPHS




Graph 1: Comparative Analysis Of NTU When Cold Water Is Constant At 45 LPH For Plane Steel Tube & Plane Copper Tube DPHE Without Insert And With 2.5" Full Length Insert In Counter Flow Arrangement.




Graph: 2 Comparative Analysis Of Heat Transfer Rate In Cold Fluid When Cold Water Is Constant At 45 LPH For Plane Steel Tube & Plane Copper Tube DPHE Without Insert And With 2.5" Full Length Insert In Parallel Flow Arrangement.

## III. CONCLUSION

In this experiment analysis of double pipe heat exchanger (DPHE) was held in heat and mass transfer lab. Double pipe heat exchanger available in same diameter and same lenght in heat exchangerlab with experiment setup. The mass flow rate inside tube and outside tube were varied as well as parallel flow and couter flow arrangement.

### *A. Conclusion and Present Study*

It was observed the heat transfer rate increased with increased from volume rate of hot water in both the cases parallel and counter flow heat transfer rate in counter flow was greater than the flow rate of parallel flow.

In both cases it was observed that the heat transfer rate in plain copper tube with 2.5 inche pitch lenth insert was greater than other three arrangement .the maximum value of heat transfer rate was found in counter flow arrangement plan copper tube with 2.5 inch insert was 795.53 watt and it is 36.95% greater than the heat transfer rate in plane steel tube with 2.5 inches pitch insert, 34.42 greater than the plane copper tube without insert and 42.05 %greater than plane steel tube with out insert. It means heat transfer rate depends on relative direction of fluid motion, variation in volume flow rate of hot fluid and pitch lenght of twisted tape.

It was observed then the maximum value of effective was found in case of counter flow arrangement with 2.56 inches insert and it was .713 and it is 15.37%, 24.21% and 34.27% greater than the maximum value of effectiveness in counter flow arrangement in case of 2.5 inches insert with plane steel tube, and plane copper tube without insert and plane steel tube without insert.

It was observed that the value of overall heat transfer coefficient increase in volume flow rate of hot fluid and maximum value of overall heat transfer coefficient was found in case of 2.5 inch insert was 697.17w/m2 K. and it is 51.57%, 43.39 % and 58.59 % greater than maximum value of overall heat transfer coefficient in with insert 2.5 inches plain steel tube and plane copper tube without insert and plain steel tube without insert respectively.

It was observer than the value of LMTD increased with increased in volume flow rate of hot fluid and maximum value of LMTD was observed in case of 2.5 inch insert was 697.17w/m2 K. and it is 11.65%, 1 % and 5 % greater than maximum value of overall heat transfer coefficient in with insert 2.5 inches plain steel tube and plane copper tube without insert and plain steel tube wit out insert respectively.

## REFERENCE

[1] Mukesh Mangtani and Prof K.M.Watt (2016) "Experimental Invistigation of heat transfer augumentation in double pipe heat exchanger with twisted tape inserts" Internation journal of mechanical engineering reserch and technology, Vol. 2, No. 4.Dec 2016

[2] Eiamsa-Ard S, Pimsarn M and Thianpong C (2014), "Performance Assessment in a Heat Exchanger Tube with Opposite/ Parallel Wing Twisted-Tapes", Department of Mechanical Engineering Faculty of Engineering Mahanakorn University of Technology, Bangkok 10530 Thailand.

[3] Maughal Ahmed Ali Baig, Ibrahim Nouzil, Azzam Sheik, Ferraz Mohammed and Thameez (2013), "Heat Transfer Augmentation in Concentric Tube Heat Exchanger Using Twisted Tapes International Journal of Engineering Research and Applications, ISSN: 2248-9622.

[4] Gawandare A V, Dange M M and Nalawade D B (2014), "Heat Transfers Enhancement with Different Square Jagged Twisted Tapes Twisted Tapes Int. Journal of Engineering Research and Applications, ISSN: 2248-9622

[5] Anil Singh Yadav (2009), "Effect of Half Length Twisted-Tape Turbulators on Heat Transfer and Pressure Drop Characteristics Inside a Double Pipe UBend Heat Exchanger", Jordan Journal of Mechanical and Industrial Engineering.

[6] Rahul Kumar A and Srinivas P N S (2013), "Experimental Analysis of Heat Transfer Augmentation by Using Twisted Tapes of Different Twist Ratio as Flow Arrangement Inside the Tubes", International Journal (IJMER), Vol. 3, No. 3, pp. 1317-1323.