# Experimental Study on Effect of Twisted Tape Insert in Double Pipe Heat Exchanger

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*Abstract*— Double pipe heat exchanger (DPHE) or concentric tube heat exchanger is one of the most simple and applicable heat exchanger. This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Double pipe heat exchanger having a relatively small diameter and it is easy to fabricate as compare to helical tube, corrugated tube and many more compact type of heat exchanger. During the experiment cold water flow rate is kept constant at 45LPH where as hot water flow rate is varies from 15LPH to75LPH. Three twisted tape inserts of different pitch length (2.5,4.5 and 6.5 inch) are used and inlet and outlet temperature and cold fluid is measured by K type thermocouple to calculate the performance of double pipe heat exchanger in parallel and counter flow arrangement.

***Key words:*** Double Pipe Heat Exchanger (DPHE)

## I. Introduction

The conversion, utilization and recovery of energy in every industrial, commercial and domestic application involve a heat exchange process.

### A. *Heat Exchanger*

Heat exchanger is a device that facilitate the exchange of heat between two fluids that are at different temperatures while keeping them from mixing with each other. Heat exchangers differ from mixing chambers in that they do not allow the two fluids involved to mix. Common examples of heat exchangers are shell-and tube exchangers, automobile radiators, condensers, evaporators, air pre-heaters, and cooling towers.

### B. *Double Pipe Heat Exchanger*

Double pipe heat exchanger (DPHE) or concentric tube heat exchanger is one of the most simple and applicable heat exchanger. This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Double pipe heat exchanger having a relatively small diameter and it is easy to fabricate as compare to helical tube, corrugated tube and many more compact type of heat exchanger.

### C. *Heat Transfer Enhancement Methods*

In general, heat transfer enhancement methods are of following three main categories.

1) Active method
2) Passive method
3) Compound method

#### 1) *Active Method*

This method addresses the issue of using an external force for increasing heat transfer rate. Typical example can be mentioned as reciprocating plungers, implementing magnetic field for flow distribution, using surface or flow vibration also applying electromagnetic fields.

#### 2) *Passive Method*

In this method, no external force is used for heat transfer enhancement. Surface or geometrical modification and various inserts play a central role in field.

#### 3) *Compound Method*

This heat transfer enhancement method is a combination of both active and passive methods. Simultaneous use of fluid vibration and wire coils can be a good example of this method in which plethora of studies have been carried out in heat exchangers.

### D. *Performance of Heat Exchanger*

The import performance of heat exchanger are:

1) Effectiveness
2) NTU
3) Heat transfer rate
4) Capacity Ratio
5) Overall heat transfer coefficient
6) LMTD

## II. Literature Review

Ahmed Alhusseny et al., (2017), Analyses a wide range of parameters including the clearance-to-vane size ratio S, foam porosity, foam thermal conductivity ks, Reynolds number ratio Re, rotational speed X, and characteristic temperature difference $\Delta T_c$, while the values of pore density, inner inlet temperature, and outer Reynolds number are kept constant at x = 10PPI, $T_{inner}$ = 30 _C, and $Re_{outer}$ = 2000, respectively. The efficiency of heat exchange process is mainly measured in terms of two key design parameters. The first is the Effectiveness of the counter-flow heat exchanger. The other key parameter in assessing the overall performance is the total pressure loss $\Delta P_t$ occurring across the heat exchanger, which indicates the pumping power required.

Mohamad Omidi et al.,(2017), studied the Effectiveness of trapezoidal-cut twisted tapes in a DPHE. The nano fluid used in this investigation was water-based $Al2O3$ which was in turbulent flow regime. The results showed that the heat transfer rate increase in the annulus was higher than that of the inner tube which this was mainly due to the secondary flows in the annulus. They also observed that the increase in nanofluid concentration and also the twist ratio leads to a higher heat transfer and pressure drop.

Paisarn Naphon et al.,(2016) studied the Effectiveness of curvature ratios on the heat transfer and flow developments in the horizontal spirally coiled tubes. The spirally coiled tube is fabricated by bending a 8.00 mm diameter, straight copper tube into a spiral coil of 5 turns. The spirally coiled tube with 3 different curvature ratios of 0.02,.04,.05,under constant wall temperature are tested.

Dillip Kumar Mohanty et al (2014); Analysis of heat exchanger fouling using previous data of a shell and tube heat exchanger has been found to be a very useful methodology to predict and consequently improve the overall performance of a process plant involved with such systems. The developed fouling prediction model provides a priori picture about the fouling behaviour of the exchanger over the next period of operation. It observed that maximum error is found to be 1.25% during training phase and 0.064% during the testing phase.

## III. Problem Identification

Most of the investigations on heat transfer coefficients are for constant wall temperature or constant heat flux. The situation of constant wall temperature is idealized in heat exchangers with phase change such as condensers. The boundary condition of constant heat flux finds application in electrically heated tubes and nuclear fuel elements. However, the case of fluid-fluid heat exchange has not been studied well. In current work the fluid to fluid heat exchange is taken into consideration and analyzed flow. Forced convection and Tube side heat transfer coefficients are taken into consideration for analysis of heat exchanger.

## IV. Experimental Methodology

- Hot water flow rates in the tube were varied. The following five levels were used: 15, 30, 45, 60 and 75LPH. All possible combinations of these flow rates in annulus and the inside the tube were tested.
- These were done for all cases of double pipe heat exchanger with and without insert, in counter flow configurations.
- The Temperature data used in the calculations was after the system had stabilized. The type-K thermocouples used for temperature readings. All the thermocouples were constructed from the same thermocouple wire, and hence the repeatability of temperature readings was high with temperature reading fluctuations within ±0.3 °C.

## V. Experimental Setup

The set-up consisted of the following components:

1) Straight Steel Tube,
2) Heater,
3) Cold water source.
4) Flow measuring devices,
5) AC power supply,
6) Thermocouples,
7) Electrical Heater Fired Hot Water Boiler,

## VI. Results & Discussion

1) Comparative analysis of Logarithm mean temperature difference when Cold fluid is constant at 45 LPH for Double pipe heat exchanger in counter flow arrangement.

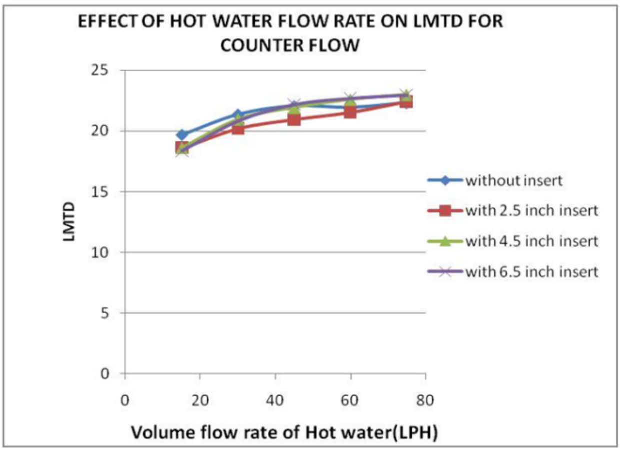


Fig. 1:

2) Comparative analysis of Overall heat transfer Coefficient when cold fluid is constant at 45 LPH for Double pipe heat exchanger in counter flow arrangement.

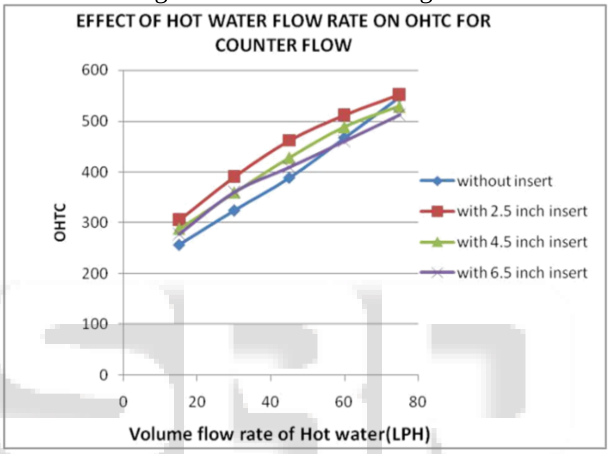


Fig. 2:

## VII. Conclusion of Present Study

It was observed that the heat transfer rate increases with increase from volume flow rate of hot water in counter flow .It was observed that the heat transfer rate in case of 2.5inch pitch length insert was greater than the other three arrangements. The maximum value of heat transfer rate was found in counter flow arrangement with 2.5inch insert was 677.28 Watt and it is 11.11% greater than the heat transfer rate in without insert, 4.83% greater than the 4.5inch insert and 13.04% greater than 6.5inch insert.

It means heat transfer rate on relative direction of fluid motion, variation in volume flow rate of hot fluid and pitch length of twisted tape.

It was observed that the maximum value of effectiveness was found in case of counter flow arrangement with 2.5inch insert and it was 0.77 and it is 37.5%, 4.05% and 11.59% greater than the maximum value of effectiveness in counter flow arrangement in case of without insert, 4.5 inch pitch length insert and 6.5 inch pitch length insert respectively.

It was observed that the value of overall heat transfer coefficient increases with 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 639.525 $W/m^2K$ and it is 29.88%, 12.19%, and 16.07%/ greater than maximum value of overall heat transfer coefficient in without insert, 4.5 inch insert and 6.5 inch insert respectively.

It was observed that the value of LMTD increases with increase in volume flow rate of hot fluid and maximum value of LMTD was observed in case of 4.5 inch insert was 22.99 C and it was 3%, 2.54% and 0.13% greater than the value found in without insert, 2.5 inch insert and 6.5 inch insert respectively.

It was observed that the initially value of NTU decrease with increase in volume flow rate of hot fluid and minimum value of NTU was found in case of without insert and it was 0.426 and it is 15.18%, 9.16% and 4.69% lesser than the value found is 2.5 inch, 4.5 inch and 6.5 inch respectively.

## VIII. Scope for Future Work

The present study needs to be extended further as suggested below.

1) Twisted tape of different length can be used for further study.
2) Twisted tape of different materials can be used for further study.
3) Twisted tape with left hand, right hand combination can be used for further study.

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