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Thermal Performance Investigation of Twisted Tube Heat Exchanger

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Abstract: ***The heat transfer which having greater importance from industrial points of view particularly in process industries and one of the best application of heat transfer is heat exchanger like condenser, evaporator, boiler etc. Nowadays with need of more efficient thermal systems with high rate of heat transfer at faster rate and with compact in size is the major requirement of new heat exchanger and to overcome such difficult in the objective of present work is to fabricate pipe in pipe liquid-liquid twisted heat exchanger and results were compare with conventional straight tube heat exchanger. The K type thermocouples are used for measurement purpose and the experimental set up is fabricated from copper pipes and copper sheets.***

Keywords: Heat exchanger, Twisted Tube

1. Introduction

The heat exchanger is the best application of heat transfer and Heat exchangers are devices used to transfer heat between two or more fluid streams at different temperatures. A large number of production facilities in many industries use processes in which heat is transferred between different fluids. The basic principle of heat transfer is extremely simple, two fluids at different temperatures are placed in contact with a conductive barrier (the tube wall) and heat is transferred from the hotter fluid to the colder fluid until they reach the same temperature level. In industrial processes this is carried out in heat exchangers of various types and styles usually purpose built for the process and site conditions of the application. The driving force for heat transfer is the difference in temperature levels between the hot and cold fluids, the greater the difference the higher the rate at which the heat will flow between them. With complex processing sequences the designer must optimize the temperature levels at each stage to maximize the total rate of heat flow.

2. Literature Review

G. E. Kondhalkar et al [1] gives the performance analysis of spiral tube heat exchanger over the shell and tube type heat exchanger. P. Naphon [2] proposed that the heat exchanger consists of a shell and helically coiled tube unit with two different coil diameters. Ashish Agarwal et al [3] experimentally investigated the role of phase change material in case of shell and tube heat storage in case of solar dryer. Lavinia Gabriela et al [4] discussed about various thermal energy storage system and their significance in the thermal system. Syukri Himran et al [5] studied thermal energy storage in paraffin-wax using tube array on a shell and tube heat exchanger. Thirugnanam. C et al [6] studied about waste heat recovery using phase change material. In the present work concentric tube heat exchanger with phase change material has been used. Ganesh Patil et al [7] developed the phase change material-based heat exchanger using organic and inorganic material. Patel, Anand et al [8] [9] documents heat transfer measurement techniques and a heat spreader thermal performance with modification in geometry using CFD for analysis. Heat exchanger has many applications like desalination [10], helical flow [11], worked as microplate heat exchanger [12], biofuel related works [13-14], solar water heater [15-18], Solar air heater [19-20] and many more.

The effort that was done in researching the twisted tube heat exchanger is shown in the current study. At long last, the paper has been updated to cover the subsequent work.

3. Experimental set up

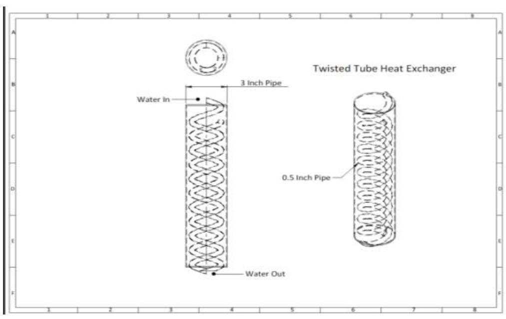

Figure 1: Proposed Experimental model

Plate 1: 4” Cylindrical pipe

Plate 2: U band Pipe Joint

Plate 3: Straight Pipe

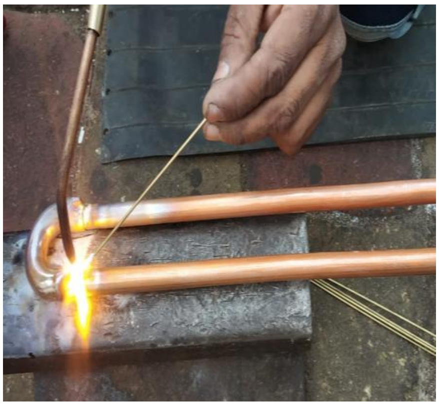

Plate 4: Brazing of Straight Pipe

Plate 5: Twisted Pipe Making Plate

Plate 6: End Pipe Connection

Plate 7: Assembly of Straight and Twisted Pipe

Plate 8: Twisted PipeHeat Exchanger

The experimental set up is fabricated in four stages:

Stage1
By using copper sheet of 0.9 mm thickness is rolled in 4" cylinder with length of 1m and two such cylinders are formed.

Stage 2
From the copper pipe of 0.9 mm thickness and 1 m in length and ½" diameter using two such pipes brazing with U band at two ends and connected with 60 mm long copper pie with U band for water in and out purpose. Similarly using specially design fixture to twist two straight pipes.

Stage 3
Assembly of twisted and straight pipes are inserted in each cylinder and completed the two whole heat exchanger units and outer surface of the cylinder is lagged with asbestos layer to avoid heat transfer to the surrounding.

Stage 4
Thermocouples at all four locations i.e. cold water inlet and outlet and hot water inlet and outlets are placed properly and water measuring flask with stop watch is used for flow measurement purpose.

3.1 Experimental methodology

In this work first of all each heat exchanger is properly placed and then through inner pipes of ½" diameter hot water is allowed to flow and hot water can be obtained using heater and at inlet of inner pipe hot water temperature is measured using thermocouple similarly cold water is flowing through cylinder inlet and proper precaution is taken to maintain flow rate of hot and cold water almost same and at exit of cylinder and inner pipe cold water and hot water temperatures are measured, respectively.

3. Result and Discussion

Table 1: Observation Table

Parallel Flow Twisted Pipe			
Hot Water Temperature ^0C		Cold Water Temperature ^0C	
Tin	Tout	Tin	Tout
70	54.5	32.5	44.5
55	47.9	33	41.4
Counter Flow Twisted Pipe			
Hot Water Temperature ^0C		Cold Water Temperature ^0C	
Tin	Tout	Tin	Tout
70	53.7	33	43.7
55	47.8	33.5	42.2
Parallel Flow Straight Pipe			
Hot Water Temperature ^0C		Cold Water Temperature ^0C	
Tin	Tout	Tin	Tout
69.8	62.7	31.4	36.5
55	50.4	31.1	35.3
Counter Flow Straight Pipe			
Hot Water Temperature ^0C		Cold Water Temperature ^0C	
Tin	Tout	Tin	Tout
69.7	60.5	31.4	37.3
55	46.5	32	37

Table 2: Result Table (Effectiveness)

$\varepsilon_{\text{Parallel flow Twisted Tube}}$
0.41
0.32
$\varepsilon_{\text{counter flow Twisted Tube}}$
0.44
0.33
$\varepsilon_{\text{Parallel Flow Strigh Tube}}$
0.18
0.19
$\varepsilon_{\text{Counter Flow Strigh Tube}}$
0.24
0.37

It is clearly observed from the experimentation work is that in case of parallel as well as counter flow in case of twisted tube heat exchanger the values of effectiveness are higher compare to straight tube heat exchanger may be because in case of twisted pipe more retention time is there which means hot water can remain in contact with cold water for longer period due to turbulence in flow and pressure drop too so better heat transfer may occur. Additionally, by changing temperature of hot water it is not influencing the values of effectiveness.

4. Conclusion

The major outcome of this research work is that the twisted heat exchanger is gives better thermal performance as compare to straight tube heat exchanger and it is also compact in size but the manufacturing cost of twisted tube heat exchanger is higher than straight tube heat exchanger; also more pressure drop in twisted tube heat exchanger which enhances heat transfer but at the same time flow rate of fluid flowing through twisted pipe also severely affected.

5. Future Scope

The present work can be extend by changing the shape of tube into helical and serpentine and compare the results of all heat exchanger to establish the best suitable shape for heat exchanger form thermal performance point of view.

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Author Profile

Anand Patel has completed his MS in Mechanical and Energy Engineering from University of North Texas with bachelor’s in mechanical engineering from LDRP-ITR. His area of research is renewable energy especially solar and biofuel. Overall, he has 15 research articles in national and internationally recognized journal.