International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Enhancing the Heat Transfer Parameters in Double Pipe Heat Exchanger by Creating Turbulence in Inner and Outer Tube

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Abstract: The main aim of this thesis is to compare and improve the various heat transfer parameters like overall heat transfer coefficient, heat transfer rate, effectiveness, NTU etc..in double pipe heat exchanger for four different cases, i.e. Plain tube, Corrugated tube, Plain tube with helically twisted wire and Plain tube with twisted clip . The above work is done experimentally on Concentric tube heat exchanger. This works falls under Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. The data obtained from experiment were used for calculating the various parameters as discussed.
Keywords: Effectiveness, Plain tube, corrugated tube, twisted clip, helical wire insert.

I. INTRODUCTION

Heat transfer enhancement methods (active, passive or a grouping of passive and active methods) are frequently used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc.

In the design of efficient heat exchangers, passive methods of heat transfer enhancement plays a vital role if a proper passive insert configuration can be selected according to the heat exchanger working condition (both flow and heat transfer conditions). In the past decade, several studies on the passive techniques of heat transfer augmentation have been reported. The present paper compares the three different methods of creating turbulence and increase the heat transfer with effectiveness.

Tube inserts present some advantages over other enhancement techniques, such as they can be installed in existing smooth tube that exchanger, and they maintain the mechanical strength of the smooth tube. The method of improving the performance of a heat transfer system is referred as the heat transfer enhancement technique.

In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment .The major challenge in designing a heat transfer is to make the device compact and achieve a high heat transfer rate using minimum pumping power. The subject of heat transfer growth in heat exchanger is serious interest in the design of effective and economical heat exchanger. Enhancement techniques increase the value of convective heat transfer by reducing thermal resistance in a heat exchanger. A decrease in heat transfer surface area, size, and hence weight of heat exchanger for a given heat duty and pressure drop.

II. LITERATURE REVIEW

The literature survey shows different passive techniques for enhancing thermal performance of heat exchanger.

Manglik and Bergles [1] given experimental data for three different twisted tapes under uniform wall temperature boundary conditions. The experiments were conducted with water and ethylene glycol as working medium. From the experimental data the author resulted that the thermal performance was improved due to developed swirl flow due to the tape twist.

Zimparov [2], investigated for heat transfer enhancement using combination of three-start spirally corrugated tubes with twisted tape. The test setup consists of three start spirally corrugated tubes combined with five twisted tape inserts with different relative pitches. The Reynolds numbers in the range from 3000 to 60000 were varied during experiments.

Promvonge et al. [3], Effects of insertion of tandem wire coil elements used as turbulator on heat transfer and turbulent flow friction characteristics in a uniform heat-flux square duct are experimentally investigated in this work. The experiment is conducted for turbulent flow with the Reynolds number from 4000 to 25000. The experimental results reveal that the use of wire coil inserts for the full-length coil, different length coil elements leads to a considerable increase in heat transfer and friction loss over the smooth duct with no insert.

Prof. Naresh B. Dhamane et al.[4]presents an experimental study of heat transfer and friction characteristics in turbulent flow generated by a helical strip inserts with regularly spaced cut passages, placed inside a circular pipe across the test section. The experiments were conducted for water flow rates in the range of Re 5000 to Re 30000.

III.METHODOLOGY

Flow rates in the inner tube were varied and that of in outer tubes were kept constant. The following Five levels were used: 65, 75, 85, 95 and 105 LPH.

These were done for following four arrangements in concentric tube heat exchanger "Plain tube without insert, Plain tube with circular twisted insert, Plain tube with twisted tape insert and Straight Corrugated tube (at 60^0thread angle)" in counter flow arrangement. The Plain as well as the Corrugated tube were made of Steel.

The Temperature data used in the mathematical calculation was after the system had stabilized. The type-K thermocouples used for temperature value. All the thermocouples were constructed from the same thermocouple wire, and hence the repeatability of temperature value was high

Table 1 Specification of tubes

Sr. No.	Parameter	Value in mm	Value
1	I.D. of Inner tube	10 mm	0.010 m
2	O.D. of Inner tube	12 mm	0.012 m
3	I.D. of Outer tube	14 mm	0.014 m
4	O.D. of Outer tube	16 mm	0.016 m
5	Eff. Length of tube	1500mm	1.5 m
6	Pitch of Corrugated tube	1.75 mm	.0175 m
7	Pitch of Wire coil an Twisted clip	4.5 inch	---------------
8	Heat Transfer Area	$47000mm^2$	$0.047 m^2$

IV.EXPERIMENTAL SETUP

The Practical set-up used for below investigation is demonstrated in figure.

The set-up consisted of the following components:

Straight Plain Steel Tube, 2. Corrugated Tube , 3. Rectangular and Circular inserts, 4. Heater, 5. Cold water source,

Flow measuring devices, 7. AC power supply, 8. Thermocouples.

Hot water flow from heater and flows inside the inner tube where it lose heat by cold water flowing through shell. The inlet and outlet of cold water in shell kept at top so shell should be filled completely and complete inner tube must be immersed in water. The flow of cold water is controlled by rotameter at the inlet in the shell, this cold water then carries heat to drainage. Hot water mass flow rate controlled after the outlet of inner tube. This is done to get counter flow arrangement.

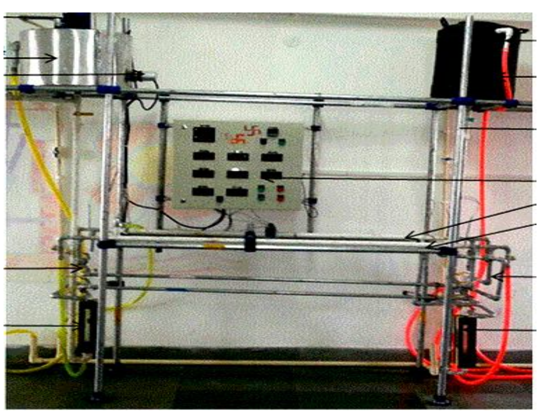


Figure 1 Practical setupFigure 2 Control Panel and Display Board

A. Counter Flow Arrangements

To analyse Counter flow in straight tube heat exchanger 4-ball valves arranged in such a way that with different combination of valves one can get counter flow. Similarly counter flow arrangement was made for corrugated tube heat exchanger.

B. Control Panel of Setup

The control panel consist all circuit of the system, the various parameter of heater, motor and temperature indicator depend on it. It helps in smooth operation of electrical equipment.

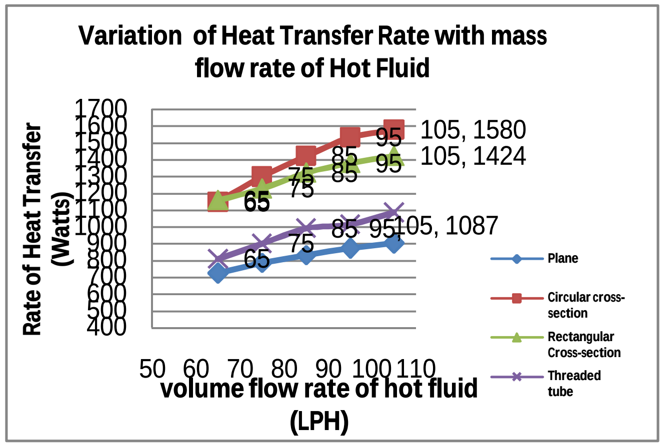
V. RESULTS AND DISCUSSIONS

A. Heat Transfer rate

After finding temperature at various point by thermocouples and tabulating these values we calculated LMTD, heat transfer rate, NTU and effectiveness for all the four cases in counter flow arrangement.

1) Hot fluid passes through inner tube and cold fluid i.e. water flows through the outer one.
2) For the turbulence in inner tube the flow rate of hot water were kept 65L/hr, 75L/hr, 85L/hr, 95L/hr and 105L/hr.
3) For corrugated tube (outer surface of inner tube) the flow rate of cold water varies from 65L/hr to 105L/hr.

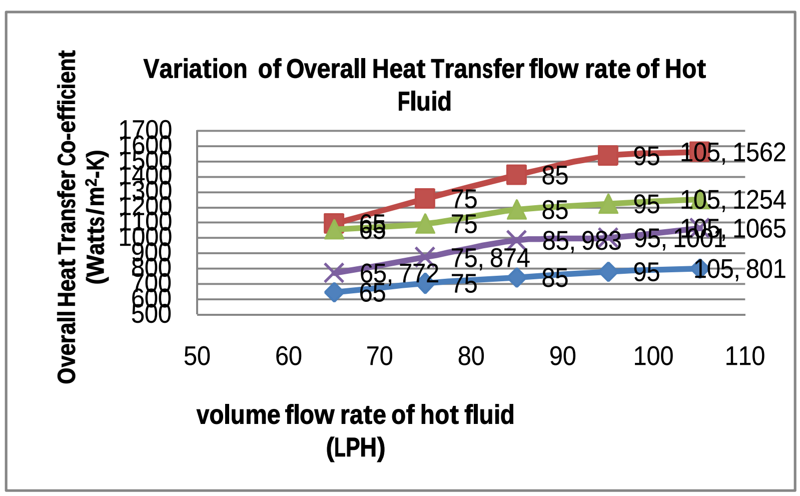
volume flow rate of hot fluid	Heat Transfer Rate			
	Plain	Helical twisted wire	Twisted clip	Threaded tube
65	725.746	1149.098	1160.438	812.68
75	788.842	1300.296	1229.64	902.82
85	832.747	1425.615	1324.429	993.24
95	874.036	1536.105	1381.419	1016.8
105	904.275	1580.883	1424.452	1087.1



C. Overall Heat Transfer Coefficient

1) The overall heat transfer coefficients were calculated by dividing the average heat transfer rate with the product of area of heat flow and LMTD.
2) By creating turbulence the overall heat transfer coefficient increases upto 1562W/m^2-k.

flow rate of hot fluid	Overall Heat transfer coefficient			
	Plain	Helical twisted wire	Twisted clip	Threaded tube
65	645	1092	1057	772
75	702	1256	1093	874
85	743	1411	1184	983
95	780	1535	1225	1001
105	801	1562	1254	1065



D. Effectiveness

A. At different flow rates the effectiveness is calculated for Plain tube without insert, with inserts and for the Corrugated tube. The values of effectiveness were increases with the insert as compared to without insert.

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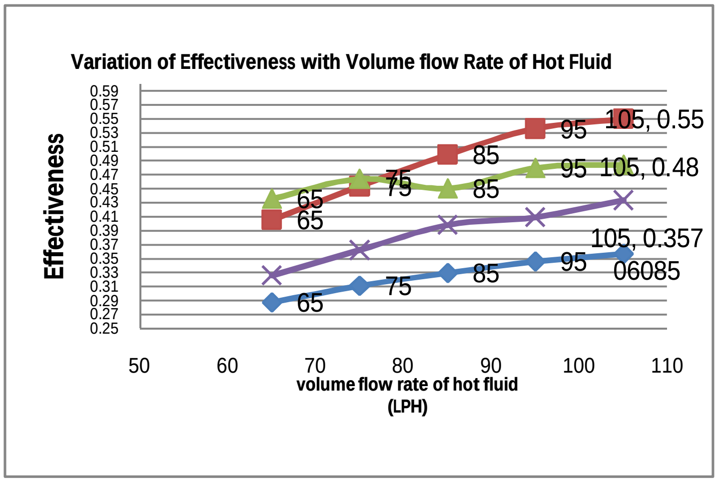
flow rate of hot fluid	Effectiveness			
	Plain	Helical twisted wire	Twisted clip	Threaded tube
65	0.287	0.405	0.436	0.32
75	0.311	0.453	0.464	0.362
85	0.329	0.498	0.450	0.398
95	0.346	0.536	0.48	0.409
105	0.357	0.550	0.484	0.433



VI. CONCLUSION

Following important conclusion were obtained from the above experimental work.

A. The value of heat transfer rate increases to 74.7% for helical wire insert. This increment is 57.5% for twisted clip and 20.2% for corrugated tube.

B. The Overall heat transfer coefficient increases to 95% for helical wire insert. This increment is 56.5% for twisted clip and 33% for corrugated tube.

C. The value of Effectiveness is optimum for helical wire insert which is 0.55.

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