THINK INDIA JOURNAL ISSN: 0971-1260
Vol-22-Issue-17-September-2019

Experimental Analysis and Contrast of LMTD and Effectiveness For Corrugated Tube (60 Degree Pitch) In Parallel Flow Arrangement With Shell and Pipe Heat Exchanger.

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Abstract:

This work focuses on the fact that corrugated heat exchanger pitch (60 degrees) is relatively more efficient in terms of heat transfer compared to the shell and tube of the heat exchanger. The corrugated heat exchanger has developed an upper hand due to the compactness and increased heat transfer coefficients. The achieve of the twist of the coil is the increased heat transfer coefficients, resulting in the growth of secondary flow. The centrifugal force and the torsion to which the fluid is subjected is administered respectively by the coil curvature and the coil pitch. With all the research findings focused on constant wall temperature, heat exchange between liquid and water is considered in the current work. The heat exchanger's efficacy was determined and the consequence of the stream of cold water on efficacy was observed, holding the flow rate of hot water mass constant, and vice versa. The data thus obtained was used in a parallel flow arrangement to perform the comparison of LMTD and efficacy for shell and tube with corrugated tube at 60 degree pitch. It was concluded that corrugated tube heat exchangers are superior in all respects upon successful completion.

Introduction

Heat exchangers are engaged in different fields of work with all due effort to improve efficiency and heat transfer by designing an effective heat exchanger that can be more compact in volume. Active and passive techniques are the key to improving the design and quality of any heat exchanger. Active techniques use external force, while passive techniques rely on different surface geometries or fluid additives. Various industrial applications deal with helical coiled tubes as one of the unreceptive technique of achieving the maximum heat transfer coefficient. Helical coiled boasts of its superiority in heat transfer applications as opposed to shells and tubes. In his work, Naphon [1] tested the temperature efficiency and pressure fall of a helically coiled as well as of shell-like heat exchanger with and without helically crimped fins. There is very little work on the goemetric effects investigation as per the literature study. The quest was based on choosing two dissimilar coil diameters, and the coils were created by twisting a straight copper pipe into a helical tube that held thirteen turns and allowed to carry varying fluid mass flow rate. The results of the study performed by Pachegaonkar et al.[2] concluded in an increase in the amount of Nusselt using an annular twist of 45 degrees over a flat double pipe heat exchanger. Prabhanjan et al.[3] framed various helical coils using an internal diameter of 12.5 mm tube. Shao Li et al.[4] used a horizontal straight and helically coiled tube heat exchanger to investigate the effect of R-134a condensation heat transfer. The condensation heat transfer coefficient was examined by Naphon et al.[5] to determine the outcome of curvature ratios on horizontally coiled tubes. Timothy et al.[6] perfected their experiments in parallel and counter-flow arrangement on a

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double-pipe helical heat exchanger in their research work. Temperature data were measured by comparing internal tube and annulus flow rates. The mean coefficients of heat transfer and coefficients of heat transfer in the inner tube and annulus were analyzed using Wilson diagrams.On the counter side, heat transfer levels were found to be higher. Jayakumar et al.[7] studied the heat exchanger as the constant temperature or constant thermal flux boundary condition of the actual heat exchanger does not produce realistic thermal conditions, considering thermal transfer and heat-dependent properties of the heat transfer media.Amit Thakur et al.[8] studied that changing the hot and cold water mass flow rate improved the heat exchanger's efficiency to a greater extent. Keeping the cold water mass flow level stable and increasing the Level of stream of hot water saw the efficiency on the lower side and vice versa.

The current work focuses on fluid-to-fluid heat exchange considering forced convection and pipe-side heat transfer coeficients for the full flow study in the heat exchanger. Corrugated coil heat exchanger was produced and the contrast was made with the available shell and tube heat exchanger in the heat transfer laboratory. Experimental results was noted to evaluate LMTD and shell and tube heat exchanger effectiveness in conjunction with 60 degree pitch corrugated heat exchanger for parallel flow condition and further analysis was performed for shell and tube and corrugated tube for LMTD and efficacy.

. **Experimental methodology:**

Experiments were performed in this research study to measure LMTD and Effectiveness for shell and pipe and corrugated heat exchanger (60 degree pitch) in parallel flow arrangement

- Various flow rates in the tube and shell. Five levels were used: LPH 15, 30, 45, 60, 75 and 90. All possible variations of these flow rates have been tested in shell and pipe inside.
- All heat exchangers (Corrugated pipe and Shell and tube heat exchangers) and parallel flow systems are carried out.
- Temperature measurement data was used after stabilization of the system. Type-K thermocouples used for temperature measurement.
- The properties of the liquid used a mean temperature of 55^0C.

Tests are carried out by escalating the level of mass flow of cold fluid and keeping the warm fluid at a constant rate, then varying the hot fluid mass flow rate and keeping the cold fluid steady. Fig.1 & Fig.2 respectively shows the investigational system and schematic diagram used for the present study.

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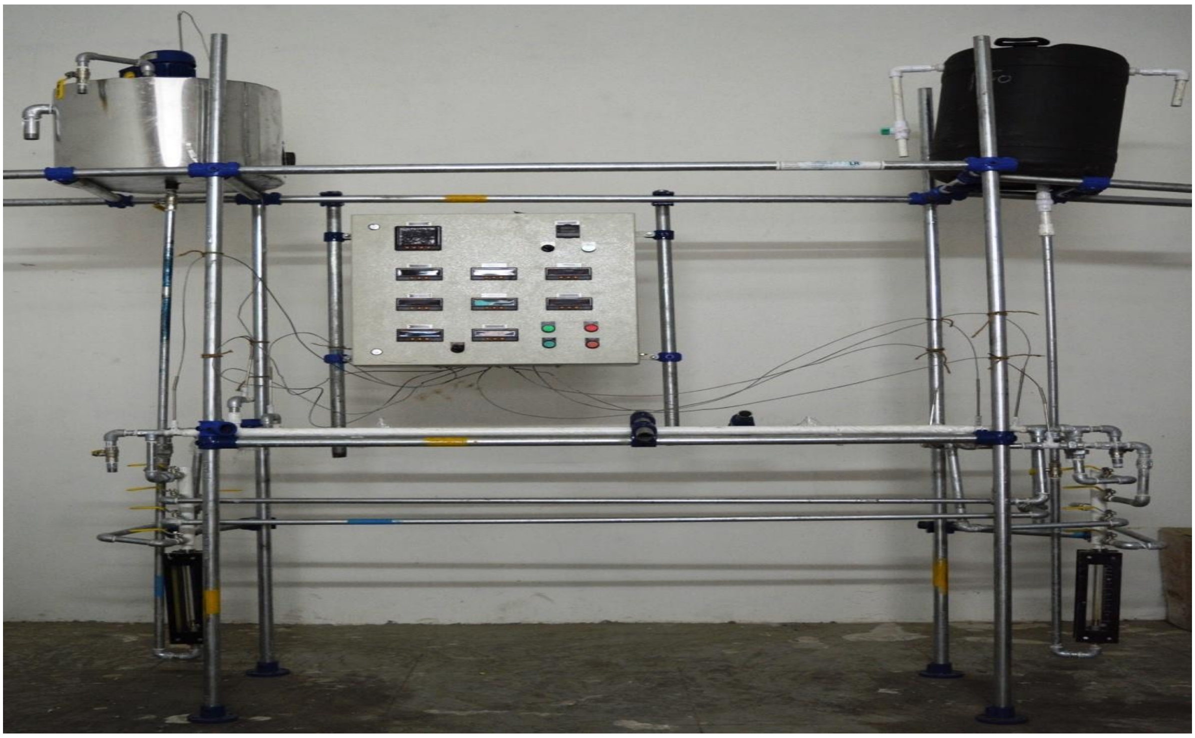

Fig. 1 Experimental Setup of Heat Exchanger

The set-up consists of the corrugated Tube (60degree pitch), plate, heater, flow measuring systems and cold water source. Energy is lost to cold water when hot water flows through the pipe.The entrance and way out of cold water in the shell is held at the apex so the shell must be completely filled and the whole coil must stay in the bath.

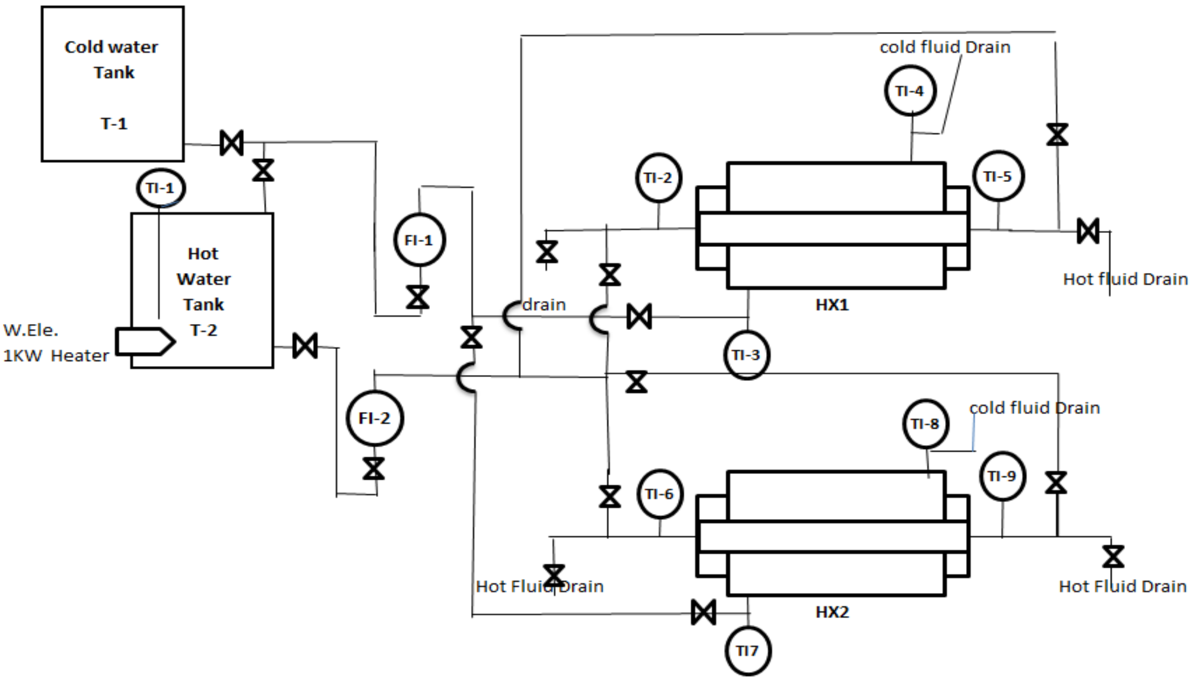

Fig. 2 Schematic diagram of Heat Exchanger

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Table 1 Dimensions for Corrugated tube

Pitch	**p**	**1.8**	**mm**
Vertical depth	**Dv**	**1.5**	**mm**
Depth	**Dt**	**1.1**	**mm**
	Dv/8	**0.2**	**mm**
	Dv/6	**0.3**	**mm**
Outside root tube diameter		**12**	**mm**
Inside root tube diameter		**10**	**mm**
Length		**1.5**	**m**
Outside main tube diameter		**14**	**mm**

Table 2 Dimensions for Plain tube

Parameter	**Unit**	**Value**
Outer Diameter Of Tube	**mm**	**10**
Outer Diameter Of Tube	**m**	**0.010**
Effective Length Of Tube	**m**	**1.5**
Heat Transfer Area	**m^2**	**0.047124**
Inside diameter of Tube	**m**	**0.008**

Rota meters are used to control cold water flow. The cold water then brings heat to drain at the shell's entrance. The mass flow rate of hot water is regulated after the helical coil exit. That is completed in order to get hold of parallel and counter flow configurations. Four thermocouples are utlized to make a note of temperature at the entrance and exit of hot and cold water flows. Table 1 & Table 2 demonstrate the corrugated heat exchanger and the heat exchanger features of the mesh and tube.

Results and discussion

Experimental results are obtained for LMTD and Effectiveness with respect to cold and level of stream of hot water

Level of stream of hot water affects on LMTD and efficiency with constant rate of flow of cold water mass

Fig.3,4,5 shows three different variations of LMTD heat exchanger with level of stream of hot water for shell- tube Parallel flow, Corrugated tube Parallel flow rate and when Rate of flow of cold water mass remains const, i.e. 45 LPH and level of stream of hot water varies (15,30,45,60,75,90) LPH rate.

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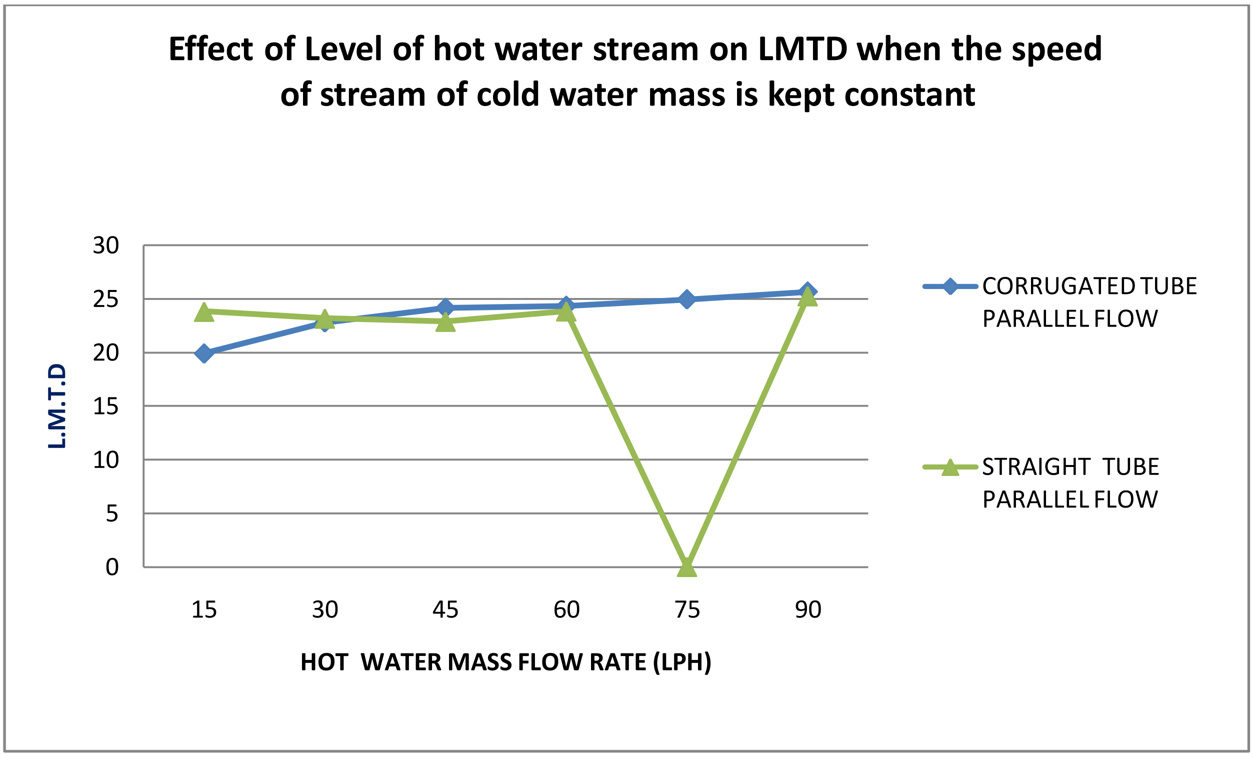

Fig. 3 Corrugated LMTD variance and heat exchanger for shells and pipes when the cold water mass flow level is 45 LPH

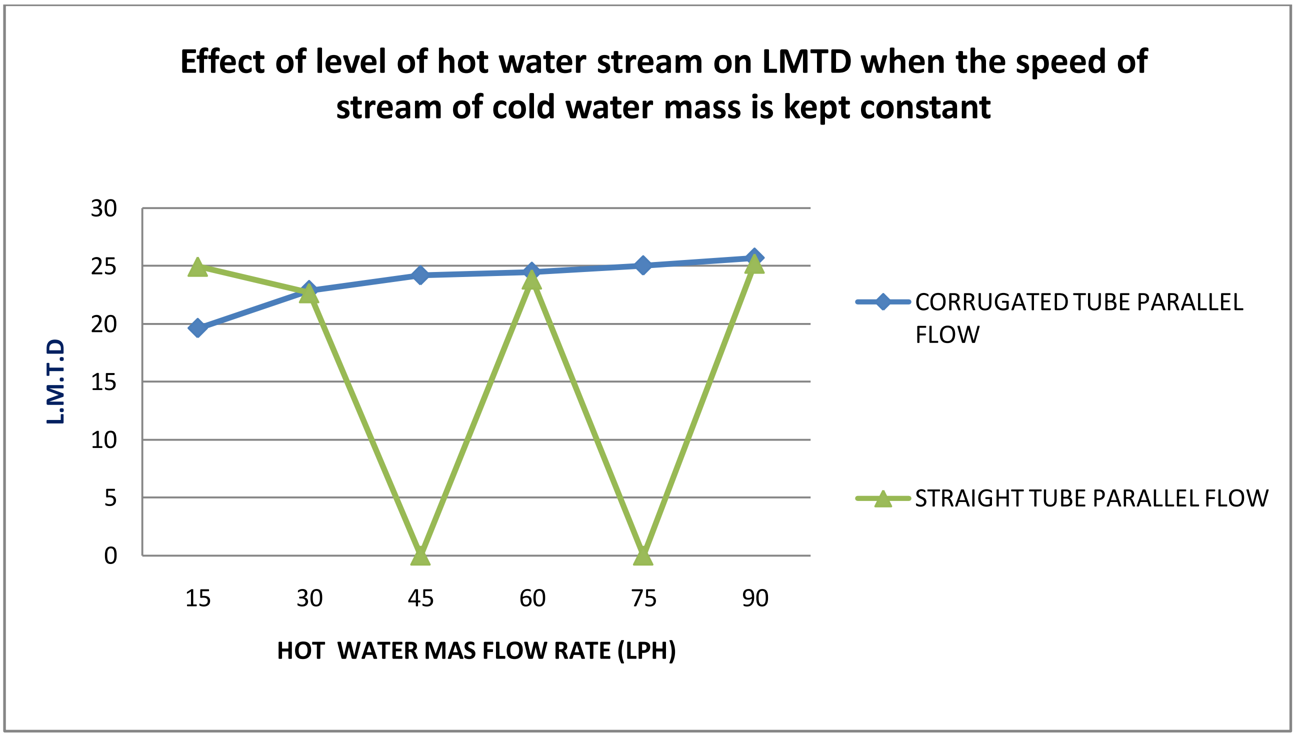

Fig. 4 Corrugated LMTD variance and heat exchanger for shells and pipes when the cold water mass flow level is 45 LPH

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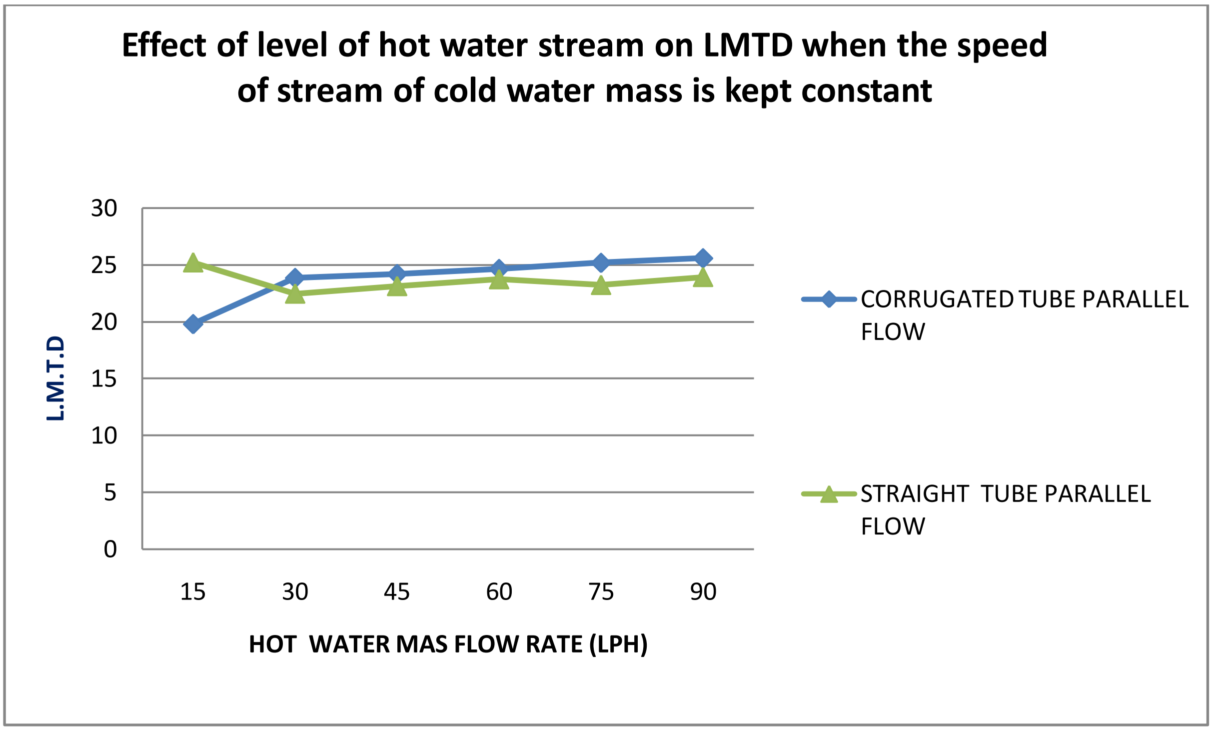

Fig. 5 Corrugated LMTD variance and heat exchanger for shells and pipes when the cold water mass flow level is 45 LPH

Corrugated tube and shell-tube heat exchanger- LMTD analysis

From the data composed from the experimental work, it is noted that LMTD tends to increase with Level of stream of hot water for corrugated tube heat exchanger. LMTD is directly proportional to level of stream of hot water. Inlet hot water temperature has a notable upshot on the heat exchanger LMTD at a given hot water mass flow rate. In the current test, the inlet heat is the highest for all mass flux rates at the third reading and the lowest when the mass flow rate is 45 LPH. From the graph, for corresponding rate of flow of cold water mass, one can easily say higher the inlet temperature higher than the LMTD. The helical coil counter heat exchanger's LMTD is the strongest followed by a parallel flow heat exchanger for shell and tube. The peak LMTD is 25.7 at a flow rate of 90 LPH for hot water and 45 LPH for cold water flow. The LMTD of the corrugated tube is 0.98 times higher than the parallel flow heat exchanger of the shell and pipe under the same operating conditions.

Corrugated tube heat exchanger delivers better results for LMTD in parallel flow arrangements. Corrugation improves the heat flow and therefore the heat exchanger performs well under the same operating condition..

Corrugated tube and shell and tube heat exchanger- Effectiveness analysis

Fig. 6 Illustrates heat exchanger variation effectiveness with level of stream of hot water for shell-tube Parallel flow rate, Corrugated tube Parallel flow rate and when Rate of flow of cold water mass remains const i.e. 45 LPH and Level of stream of hot water varies (15,30,45,60,75,90) LPH.

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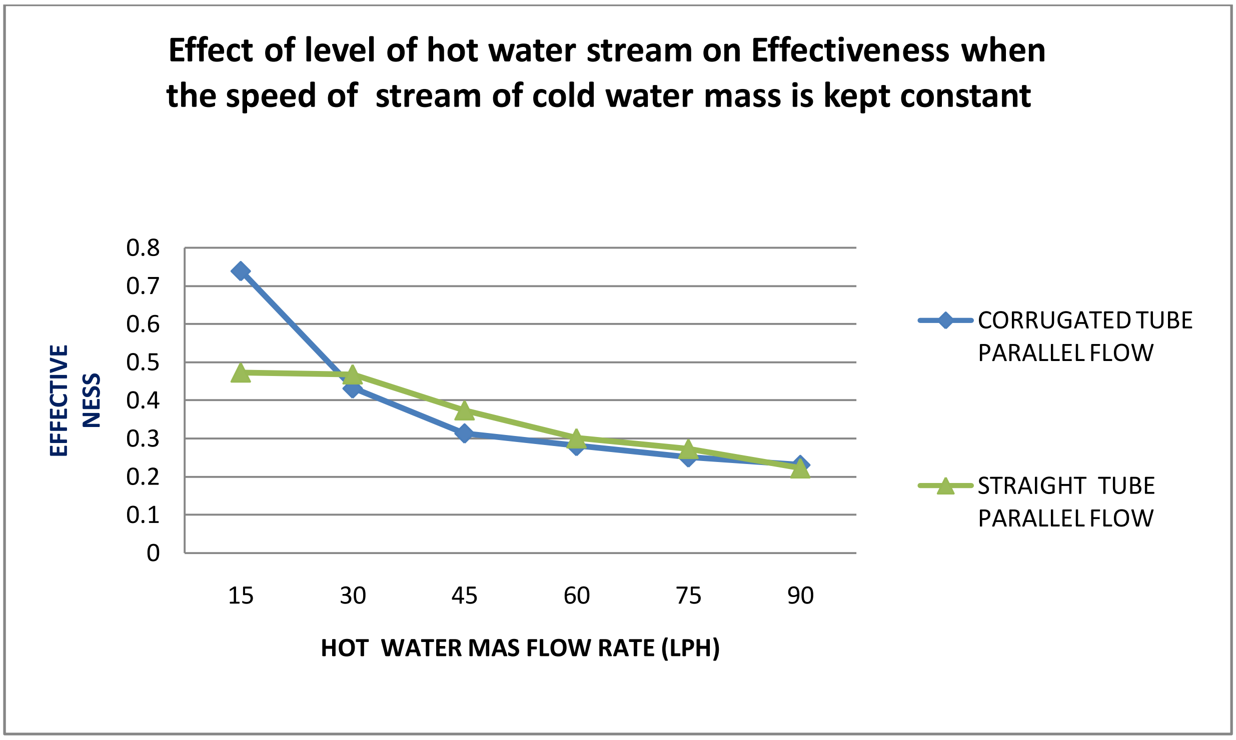

Fig. 6 Variation of corrugated efficiency and heat exchanger for shells and tubes when the Rate of flow of cold water mass is 45LPH

It is found from the data gathered from the experimental work that the effectiveness of the corrugated tube heat exchanger decreases with the rising value of the hot water mass flow rate. For shell- tube heat exchanger at the similar hot water mass flow rate, a peak value of 0.76 is noted at 15 LPH as opposed to 0.49. Recent analysis shows a decline in productivity as the hot water flow rate increases. From the chart one can easily say that the efficacy of corrugated and flat tube heat exchanger remains equivalent, raising the level of stream of hot water from 60 LPH to 90 LPH.

Therefore, corrugated tube heat exchanger in parallel flow arrangements gives better efficiency results at lower hot water mass flow rate. Corrugation improves heat flow and therefore the heat exchanger performs well under the same operating condition.

Effect of Rate of flow of cold water mass on LMTD and Effectiveness in maintaining constant level of hot water mass flow

Fig.7,8,9 confirms the difference in LMTD and Effectiveness with Rate of flow of cold water mass for shell and pipe Parallel flow, Corrugated tube Parallel flow rate and if Level of stream of hot water stays const, i.e. 45 LPH and Rate of flow of cold water mass is adjusted for the following LPH values (15,30,45,60,75,90).

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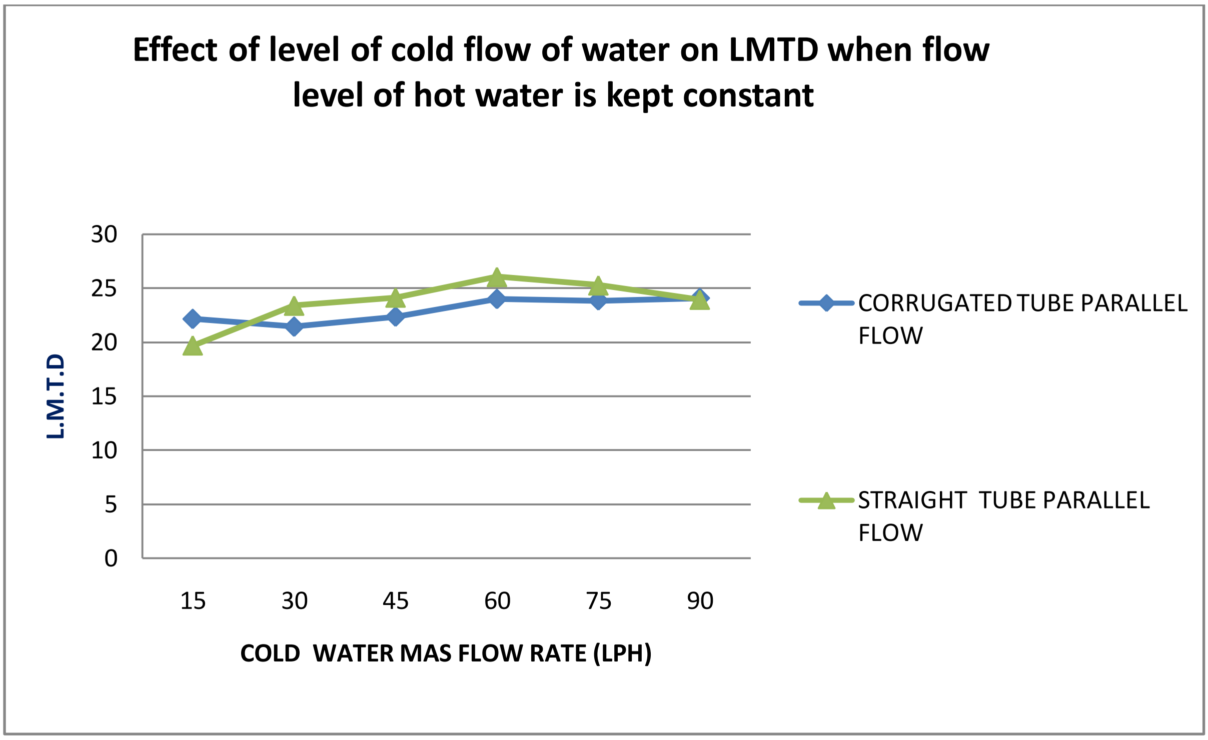

Fig.7 Corrugated LMTD variation and heat exchanger for shells and tubes when the level of mass flow of hot water is 45 LPH

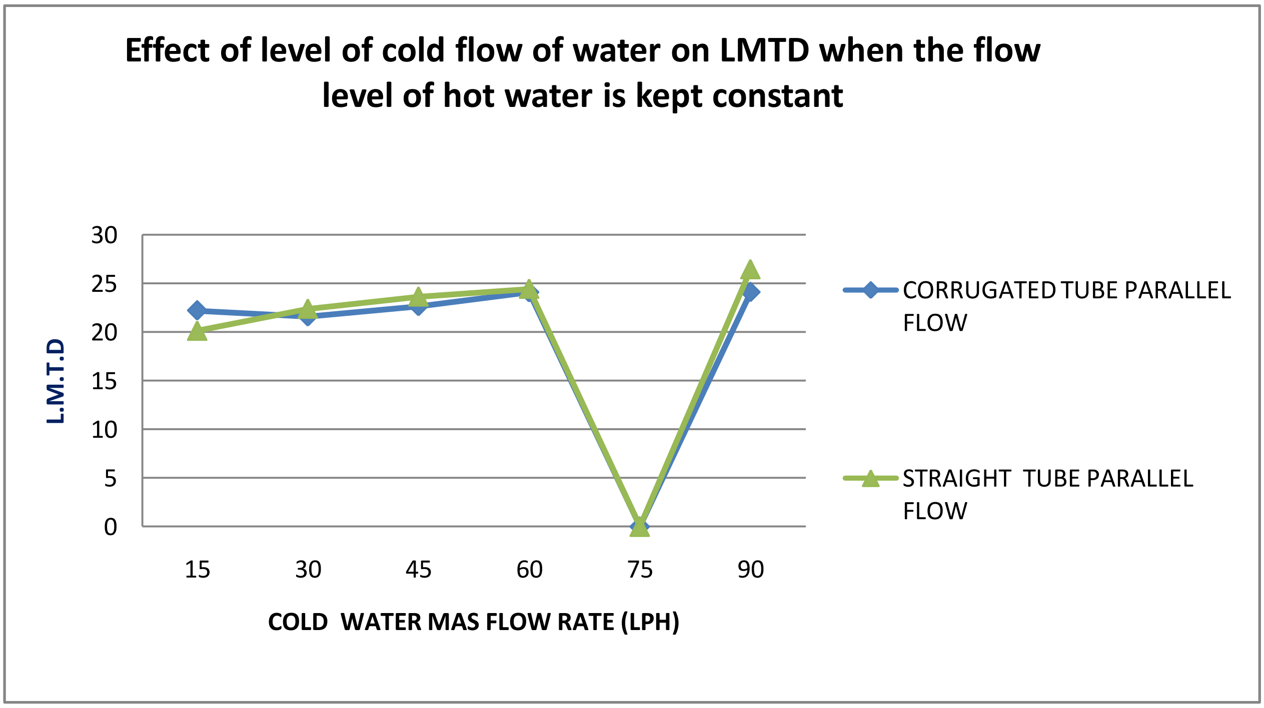

Fig.8 Corrugated LMTD variance and heat exchanger for shells and pipes when the level of mass flow of hot water is 45 LPH

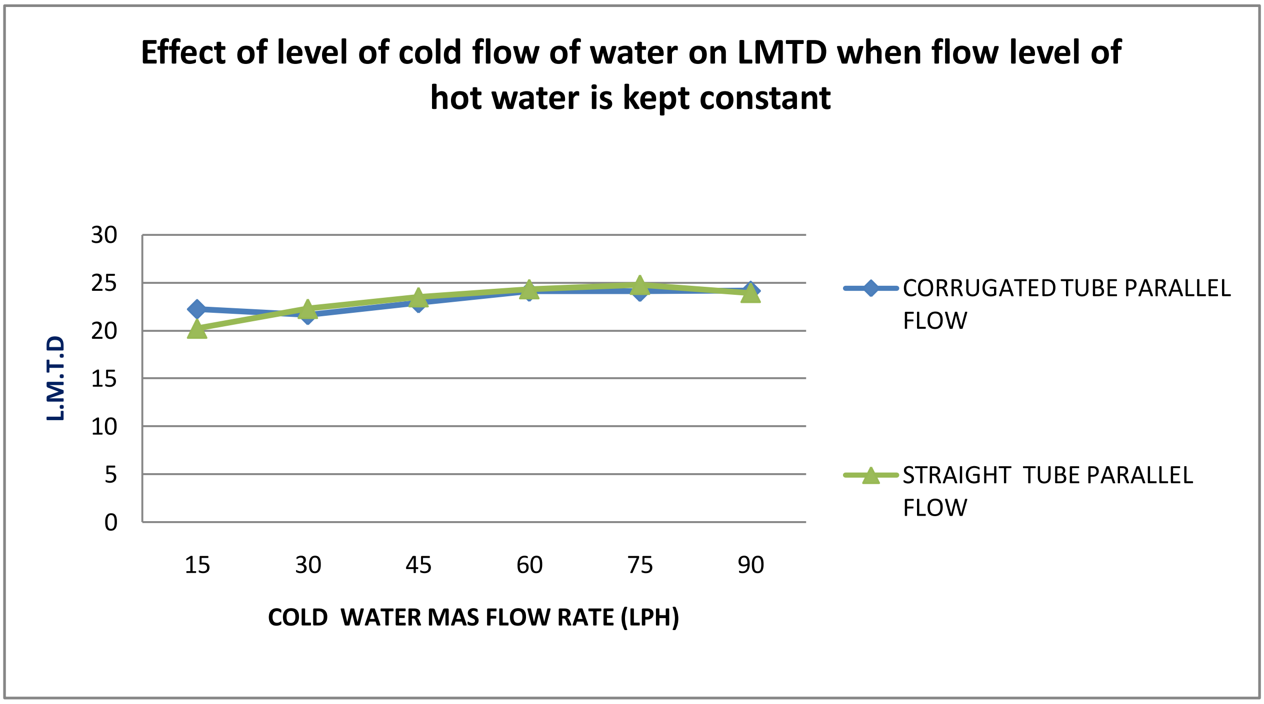

Fig.9 Corrugated LMTD variance and heat exchanger for shells and pipes when the level of mass flow of hot water is 45 LPH

Corrugated tube and plain tube heat exchanger- LMTD analysis

From the data collected from the experimental work, it is established that the LMTD increased at 15 LPH and then tends to decrease for corrugated tube heat exchanger with increasing Rate of flow of cold water mass . LMTD depends on the flow rate of cold water mass. The inlet hot water temperature has a significant effect on the heat exchanger LMTD at an accepted Rate of flow of cold water mass . The inlet temperature at the third reading for all mass flow rates is the highest in current research and the lowest when the mass flow rate is 90 LPH. From the graph, for corresponding hot water mass flow rate, one can easily say higher the inlet temperature higher than the LMTD. The corrugated flow heat exchanger's LMTD is lower, followed by a parallel flow heat exchanger for shell and pipe. At Rate of flow of cold water mass , the peak LMTD is 23.6, 15 LPH and 45 LPH is the hot water flow rate. The LMTD of the corrugated tube is 0.95 times lower than the parallel flow heat exchanger of the shell and pipe under the same operating conditions.

Corrugated tube heat exchanger does not yield better results for LMTD in parallel flow arrangements. Corrugation under the same operating condition shows no improvement in the heat flow.

Corrugated tube and plain tube heat exchanger- Effectiveness analysis

Fig.10 show heat exchanger variation Effectiveness with rate of flow of cold water mass for shell-tube parallel flow, Corrugated tube parallel flow rate and when level of stream of hot water remains const i.e. 45 LPH and varied rate of flow of cold water mass (15,30,45,60,75,90) LPH.

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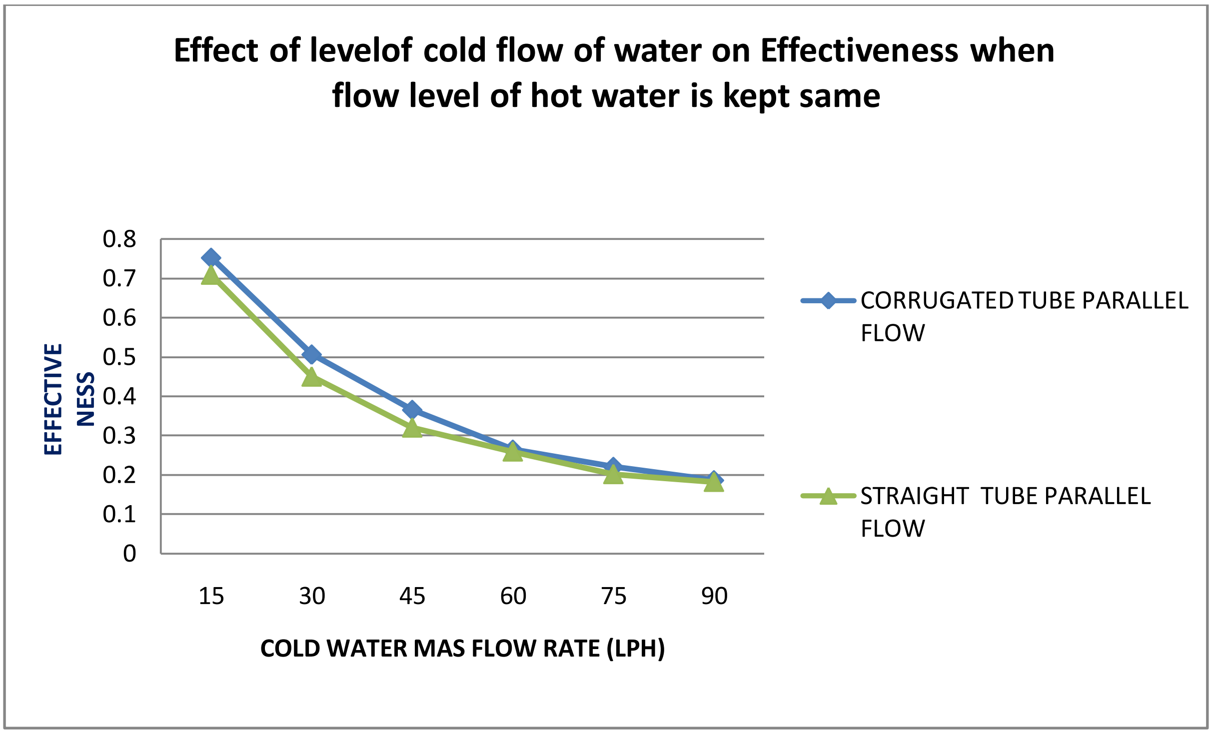

Fig. 10 Variation in the efficiency of corrugated and shell-tube heat exchangers when the mass flow rate is 45LPH

It is noticed from these statistics that the effectiveness continues to decline as the mass flow rate of cold water increases. In nature, the chart is linear. Efficiency depends upon the cold water mass flow level. The heat exchanger's efficiency improved with the variation in hot water temperature. The helical coil heat exchanger established to be more effective in preserving the inlet temperature.

Conclusion

In heat exchanger Lab, an experimental study was conducted on a corrugated tube and shell-tube heat exchanger. Considering the size and the length of the tube as same, shell -tube and corrugated tube heat exchanger were produced. At a pitch of 60 degree, one tube corrugated and another kept one straight. Shell measurements were greatly varied in experimental setup. The level of mass flow of the inner tube and annulus were mottled and parallel flow configurations were investigated.The outcome of the experimental work displayed following results.

1. Level of stream of hot and cold water flow rate influenced the heat exchanger's effectiveness.
2. When the cold water mass flow level was maintained, the efficiency decreased and the Level of stream of hot water increased.
3. Increased Rate of flow of amount of cold water increases efficiency for constant mass flow of hot water. This result was obtained for the parallel configuration of both corrugated tube and tube heat exchangers.

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