Design and Study of Triangular Plate and Fin Heat Exchanger

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Abstract - *In this present day, double pipe heat exchanger is the most common type of heat exchanger widely use in oil refinery and other large chemical processes because it suits high-pressure application.*

A heat exchanger is a device used for the transfer of thermal energy between two or more fluids that are at different temperatures. The present work demonstrates the application of triangular fins to heat exchanger, which enhances the coefficient of heat transfer of heat exchanger. The work presents an experimental comparison of three models of double pipe heat exchanger. It consists of two concentric tubes in which the hot water flows through the inner tube while the cold water flows through the outer tube. The coefficient of heat transfer is computed by L.M.T.D. method for different flow rates for the three models.

Key Words: Heat exchanger, solid edge design, triangular fins, L.M.T.D. (Logarithmic Mean Temperature Difference) method, flow rate.

1. INTRODUCTION

Heat exchanger is a device used for affecting the process of heat exchange between two fluids hot and cold.

A Heat exchanger is a piece of equipment built for efficient heat transfer from one fluid to another.

In last few years so many research have been done for enhancing the heat transfer rate like inserting baffles, twisted tapes, brushes, etc. This leads to increase in weight of heat exchangers and cost of manufacturing. The worldwide researchers are making hard efforts to find out suitable alternatives for heat exchangers with different geometry and varying parameters, which effects on performance of heat exchanger. Now days use different technique to increase heat transfer i.e. increase area by different arrangements.

This experiment area increase by using triangular portion attached on internal copper tube by helically attached. The two primary Classifications of heat exchangers according to their flow arrangement are Parallel flow and Counter flow. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side and in counter-flow heat exchangers, the fluids enter the exchanger from opposite.

2. Design

2.1 HEAT EXCHANGER SPECIFICTION

Inner tube: Material used: Copper
Inner diameter (di) = 37mm
Outer diameter (do) = 40mm
Outer tube: Material used: Mild steel
Inner diameter (Di) = 71mm
Outer diameter (Do) = 75mm
Length of the heat exchanger = 390mm

2.2 FIN SPECIFICATION

Number of triangular fins = 25
Dimensions: Base = 15mm
Slant height of copper triangle=15mm

2.3 EXTENDED PORTION OF COPPER TUBE ATTACHED TO THE INNER TUBE OF COPPER TUBE SPECIFICATION

Length of tube=80mm*2
Diameter =12.7mm

3. DESCRIPTION

3.1 MODEL-1

Model first consist plane cylindrical tube with parallel flow of water. It consists of two concentric tubes in which the hot water flows through the inner tube while the cold water flows through the outer tube in same direction. Hot water employed as hot fluid, which is coming from hot source and cold water employed as cold fluid, which is coming from cold source.

3.2 MODEL-2

Model two consist of plane cylinder tube with counter flow of water. it consist of two concentric tube in which the hot water flow throw the inner tube while the cold water flow throw the outer tube in opposite direction to each other. Hot water is employed as hot fluid, which is coming from hot source and cold water is employed as cold fluid, which is coming from cold source.

3.3 MODEL-3

Model third consists of cylinder with triangles and flow is parallel flow. It consist of two concentric tubes in which copper triangular portion externally attached to the internal copper tube, in which hot water flow through the inner tube while the cold water flow through the outer tube in same direction. Hot water employed as hot fluid, which is coming from hot source and cold water employed as cold fluid, which is coming from cold source.

4. SOLID EDGE MODEL

Fig -1: SOLID EDGE MODEL

We design the Solid Edge model for this experimentation, which shows in figure -1.
Using solid edge make a assembly of heat exchanger with copper tube and steel tube. In this above shows blue colored tube is steel, brown tube is copper tube both side fitted pipe clamps.

Triangular fins in 25 number equally brazed on surface of the copper tube. The length of copper tube is 390 mm and 40mm diameter, which is fitted inside the steel tube shows in blue color. The length of steel tube is 400 mm and diameter is 75 mm both side extended copper connector is 80 mm.

5. PROCEDURE

As shown in the figure-2 setup consists of temperature meters, flow meter, valves, water motors and two reservoirs. Valve provided for hot water is opened and water is allowed to flow through the inner copper tube. Cold-water valve is opened and it is led through the cold reservoir.

This hot and cold-water flow rate is adjusted by means of the adjusting valve provided; its flow rate is measured by means of stopwatch, and measuring flask. The temperatures of both the hot and cold water are observed at their inlets and outlets after attaining a steady state. These observed readings are tabulated.

Fig -2: ACTUAL EXPEREMENTAL SETUP

6. ANALYSIS OF HEAT EXCHANGER

1. According to first law of thermodynamics, heat transfer rate from hot fluid is equal to cold fluid is given by,

- Hot fluid heat transfer rate Qh= mh*Cph*(Thi-Tho)
- Cold fluid heat transfer rate Qc= mc*Cpc*(Tco-Tci)

Where,
mh and mc are the mass flow rates of hot and cold fluid respectively,
Cph and Cpc are the specific heats of hot and cold fluid respectively,
Thi and Tci are hot and cold inlet temperatures respectively,
Tho and Tco are hot and cold outlet temperatures.
Then average of both of them is taken for further calculation as shown below,

Qavg = (Qh + Qc)/2

2. Logarithmic mean temperature difference (LMTD) is calculated by using formula,

$$LMTD = \frac{(Thi - Tci) - (Tho - Tco)}{\ln \frac{(Thi - Tci)}{(Tho - Tco)}}$$
(For parallel flow)

$$LMTD = \frac{(Thi - Tco) - (Tho - Tci)}{\ln \frac{(Thi - Tco)}{(Tho - Tci)}}$$
(For counter flow)

3. The surface area is calculated as

As=π*D*L+n (b*h)

4. The overall heat transfer coefficient is calculated by using formula,

Qavg= U*As*LMTD

7. RESULTS AND DISCUSSION

In this section, the performance of plate and fin heat exchanger is studied. Fig. 1 shows the overall heat transfer coefficient versus the readings taken (1, 2, and 3). In order to study of three models of the heat exchangers, coefficient of heat transfer is observed to be higher for model-3 i.e. heat exchanger with triangular fins attached to the outer surface of the copper tube. From Chart- 1, the order of coefficient of heat transfer for the three proposed models is observed to be: U1<U2<U3. Coefficient of heat transfer of heat exchanger with fins attached to outer surface of copper tube is more than the other two heat exchangers because the fluid in outer tube is subjected to turbulent flow.

The surface area of inner pipe through which heat transfer occurs, from hot water to cold water is increased and also because of the arrangement of fins, a turbulent flow is created in the fluid flowing in the outer tube. Thus, it is conclude that coefficient of heat transfer of heat exchanger with fins attached to outer surface of copper tube is higher than the other two models of heat exchangers.

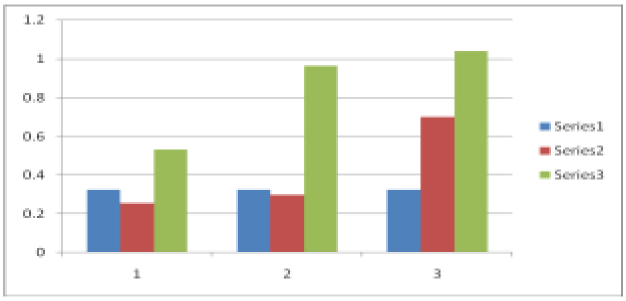

Chart -1

Y-axis shows readings of coefficient of friction U, where X axis 1, 2, 3 readings.

Series1=U1
Series2=U2
Series3=U3

Table -1: Inlet and Outlet Temperatures of Hot and Cold Water for Various Flow Rates for Parallel Flow Plain Heat exchanger (without fins)

Sr. No.	HOT				COLD				Qavg	U
	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho		
1	200	0.005	76	56	195	0.0051	35	47	0.3374	0.3262
2	152	0.0065	75	62	208	0.0048	38	49	0.2874	0.2556
3	65	0.0153	77	63	120	0.0083	34	48	0.6916	0.5308

Table -2: Inlet and Outlet Temperatures of Hot and Cold Water for Various Flow Rates for Counter Flow Plain Heat Exchanger

Sr. No.	HOT				COLD				Qavg	U
	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho		
1	200	0.005	76	56	195	0.0051	38	47.5	0.3107	0.2775
2	152	0.0065	76	57.5	208	0.0048	34	47	0.3823	0.2983
3	65	0.0153	75	51	120	0.0083	35	48	0.9945	0.9654

Table -3: Inlet and Outlet Temperatures of Hot and Cold Water for Various Flow Rates for Heat Exchanger with External Fins

Sr. No.	HOT				COLD				Qavg	U
	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho	Flow rate (sec/lit)	mh (lit/sec)	Thi	Tho		
1	200	0.0050	73	52	195	0.0051	36	51	0.3799	0.7082
2	152	0.0065	74.5	57.5	208	0.0048	37	56	0.422	0.7016
3	65	0.0153	84	62	120	0.0083	38	57	1.034	1.0409

8. CONCLUSIONS

In order to study of three models of the heat exchangers, coefficient of heat transfer is observed to be higher for model-3 i.e. heat exchanger with triangular fins attached to the outer surface of the copper tube. From chart 1, the order of coefficient of heat transfer for the three proposed models is observed to be:

U1<U2<U3

Coefficient of heat transfer of heat exchanger with fins attached to outer surface of copper tube is more than the other two heat exchangers because the fluid in outer tube is subjected to turbulent flow.

The surface area of inner pipe through which heat transfer occurs, from hot water to cold water is increased and also because of the arrangement of fins, a turbulent flow is created in the fluid flowing in the outer tube.

Thus, it is conclude that coefficient of heat transfer of heat exchanger with fins attached to outer surface of copper tube is higher than the other two models of heat exchangers.

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NOMENCLATURE

U1: Coefficient of heat transfer of plane heat exchanger with parallel flow

U2: coefficient of heat transfer of plane heat exchanger with counter flow

U3: coefficient of heat transfer of heat exchanger with external fin and parallel flow

Qh : Heat transfer rate of hot water (kW)

Qc : Heat transfer rate of cold water (kW)

mh : Flow rate of hot water (lit/sec)

mc : Flow rate of cold water (lit/sec)

Cph : Specific heat at constant pressure of hot water (kJ/kgK)

Cpc : Specific heat at constant pressure of cold water (kJ/kgK)

Thi : Temperature of hot water at inlet (°C)

Tho : Temperature of hot water at outlet (°C)

U : heat transfer coefficient (kW/m2K)

L.M.T.D.: Logarithmic Mean Temperature Difference as surface area

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