Enhancement of Overall Heat Transfer Coefficient LMTD Effectiveness of Spiral Tube Heat Exchanger for Counter Flow and Parallel Flow

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Abstract- *Heat exchanger form an integral part of the process industry. Heat exchangers used in pharmaceutical and chemical industry find suitability of conventional high conductive material like copper and aluminum suitable for larger heat transfer rates and higher production rates, but in some special cases because of the corrosive nature of the working fluid it not suitable to use such materials. In such cases the application of the non-reactive materials like polymers is advised. Though the polymers exhibit very low heat transfer rates, it is observed that they are effective means to conduct and construct such heat exchangers in minimum cost.*

Keywords- PS (Poly Phynelene Sulphide, Spiral tube , Counter flow.

I. INTRODUCTION

One of the important processes in engineering is the heat exchange. The means of heat exchanger that to transfer the heat between flowing fluids. A heat exchanger is the process to transfer heat from one fluid to another fluid. The heat exchanger is devise that used for transfer of internal thermal energy between two or more fluids at different temperatures. In air-conditioning, refrigeration, and energy-recovery applications, space heating, power stations, and petroleum plants heat exchangers are very important to the overall efficiency, cost, and size of the system. Currently, these applications rely heavily on fin-and-tube or plate-fin heat exchanger designs, often constructed using copper, aluminum, or steel. These materials are not suitable where non- reactive, fouling free materials are required. So for these conditions, one of the materials used is polymer. Polymers are large organic molecules consisting of a series of repeating units, called monomers, connected to each other. A polymer is primarily made out of hydrogen and carbon atoms, arranged in long chains. Advantages of polymeric materials are a high chemical degradation stability, corrosion resistance and price stability,but usually they have very low thermal conductivities.

II. EXPERIMENTAL SET UP

Polymer spiral tube heat exchanger set up consists of a concentric tube exchanger mounted on a support frame. Four temperature measuring devices are installed in both the inside and outside tubes, to measure the fluid temperatures accurately. To minimize losses in the system, the hot water is fed through the inner pipe, with the cooling water in the outer annulus. Circulation to the heat exchanger is provided by a pump. Heat exchanger should be such that it can transfer maximum heat. Also there should be minimum sling so that it can work effectively for long duration. Hence heat exchanger is designed accordingly by using Fluro polymer. Then the different components of the test rig are selected according to the requirement. The complete test rig is fabricated.

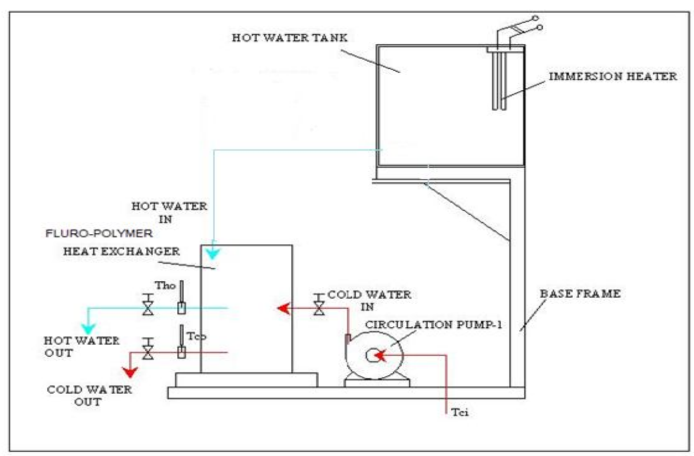

Fig. 1.Polymer spiral tube heat exchanger set up

A. Methodologies

The hot water enters through the inlet header by effect of gravity from the tank with heater. The circulation pump is connected to the shell side with help of flow control valve. The sell side water flows in either directions there by parallel and counter flow configurations are possible
1. Polymer spiral tube heat exchanger set up will be conducted by changing both the hot water and the cooling water flow rates and taking the temperature readings at steady state.

Repeat the experiment for several combinations of water flow rates.

2. Values of LMTD, Effectiveness, Capacity ratio and overall heat transfer coefficient are calculated by experimental and theoretical method.

Fig.2.Polymer spiral tube heat exchanger set up.

III. OBSERVATION TABLE(SET NO.1)

A. Mass flow rate of hot and cold water for Counter flow configuration

Table No. 1 Mass Flow rate of Hot Water (for counter flow)

Sr. No.	Volume in Beaker (ml)	Time (Seconds)	Mass Flow(Kg/Sec)
1.	200	41	0.004878049
2.	400	78	0.005128205
3.	600	114	0.005263158
4.	800	147	0.005442177
5.	1000	185	0.005405405

Table No. 2 Mass flow rate of cold water (for counter flow)

Sr. No.	Volume in Beaker (ml)	Time (Seconds)	Mass Flow (Kg/Sec)
1.	200	18	0.011111111
2.	400	34	0.011764706
3.	600	50	0.012
4.	800	65	0.012307692
5.	1000	81	0.012345679

B. Temperature of hot and cold water for counter flow configuration

Table No. 3 Temperature of hot and cold water (for counter flow)

Sr. No.	Cold Water Inlet Temp. (Tci)	Cold Water Outlet Temp (Tco)	Δt for Cold Water	Hot Water Inlet Temp. (T_{hi})	Hot Water Outlet Temp. (T_{he})	Δt for Hot Water
1.	28	41	13	90	55	35
2.	28	39	11	89	53	36
3.	28	38	10	90	52	38
4.	28	36	08	88	49	39
5.	28	35	07	92	51	41

Observation Table (Set No. 2)

C. Mass flow rate for hot and cold water for Parallel flow configuration

Table No. 4 Mass flow rate of hot water (for parallel flow)

Sr. No.	Volume in beaker (ml)	Time (seconds)	Mass flow (kg/sec)
1.	200	41	0.004878049
2.	400	78	0.005128205
3.	600	114	0.005263158
4.	800	149	0.005369128
5.	1000	185	0.005405405

Table No.5 Mass flow rate of cold water (for parallel flow)

Sr. No.	Volume in beaker (ml)	Time (seconds)	Mass flow (kg/sec)
1.	200	18	0.011111111
2.	400	34	0.011764706
3.	600	50	0.012
4.	800	66	0.012121212
5.	1000	82	0.012195122

D.Temperature of hot and cold water for Parallel water

Table No. 6 Temperature of hot and cold water (for parallel flow)

Sr. No.	Cold Water Inlet Temp. (Tci)	Cold Water Outlet Temp (Tco)	Δt for Cold Water	Hot Water Inlet Temp. (Thi)	Hot Water Outlet Temp. (The)	Δt for Hot Water
1.	28	38	10	90	60	40

2.	28	37	9	89	61	38
3.	28	35	8	90	63	37
4.	28	34	6	91	66	35
5.	28	33	5	90	66	34

IV. RESULTS AND DISCUSSION

A. Results Table for Counter flow

Table No. 7. Results of counter flow configuration

Sr. No.	mCpΔT (Hot Water)	mCpΔT (Cold water)	LMTD	Capacity Ratio	U (W/ m^2k)	Effectiveness
1.	0.8374	0.604789	33.04615	0.439024	386.7713	0.555556
2.	0.8374	0.541847	34.10558	0.435897	434.1993	0.590164
3.	0.8374	0.50244	36.21361	0.438596	456.0928	0.612903
4.	0.82031	0.412258	37.26328	0.442177	484.2834	0.639344
5.	0.792135	0.36184	40.39588	0.437838	499.8091	0.66129

B. Results Table for Parallel flow

Table No. 8 Results of parallel flow configuration

Sr No.	MCpΔT (Hot Water)	mCpΔT (Cold water)	LMTD	Capacity Ratio	U (W/ m^2k)	Effectiveness
1.	0.816976	0.465222	41.19464	0.439024	323.8893	0.5483870
2.	0.815928	0.443329	41.78304	0.441558	331.1778	0.5555560
3.	0.815363	0.401952	44.32624	0.438596	362.8125	0.596774
4.	0.786819	0.304509	46.86036	0.442953	390.1646	0.622951
5.	0.769503	0.255305	46.86036	0.443243	391.1653	0.645161

V. GRAPH

A. For Counter flow configurations.

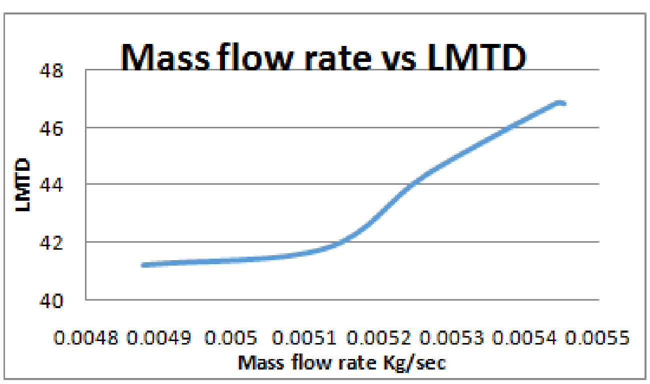

Fig.3. Mass flow rate of hot water versus LMTD (for counter flow)

From this graph of mass flow rate of hot water versus LMTD for counter flow, that the LMTD of heat exchanger goes on increasing with increase in mass flow rate.

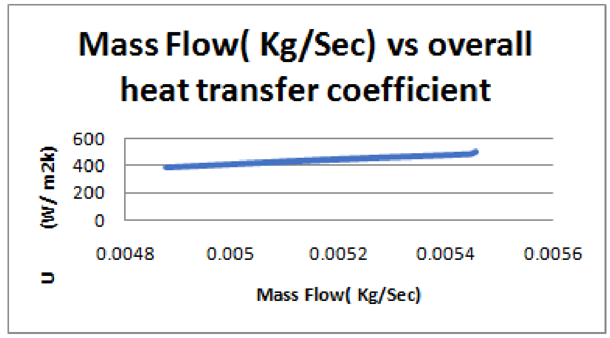

Fig.4. Mass flow rate versus U (for counter flow)

From this graph of mass flow rate versus U, that the overall heat transfer coefficient of heat exchanger goes on increasing with increase in mass flow rate.

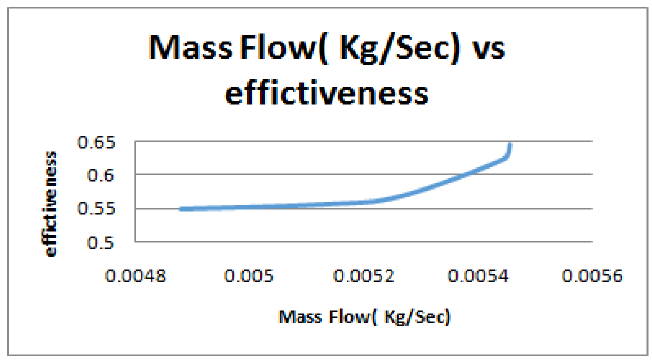

Fig.5. Mass flow rate versus Effectiveness (for counter flow)

From this graph of mass flow rate versus Effectiveness for counter flow, the effectiveness of heat exchanger goes on increasing with increasein mass flow rate in counter flow condition.

B. For parallel flow configuration

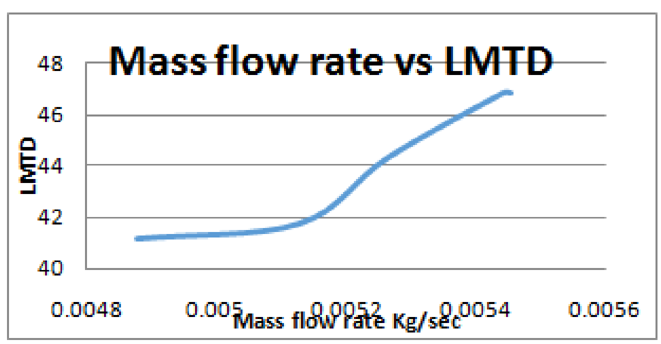

Fig. 6.Mass flow rate of hot water versus LMTD (for parallel flow)

From this graph of mass flow rate of hot water versus LMTD for parallel flow, the LMTD of heat exchanger goes on increasing with increase in mass flow rate.

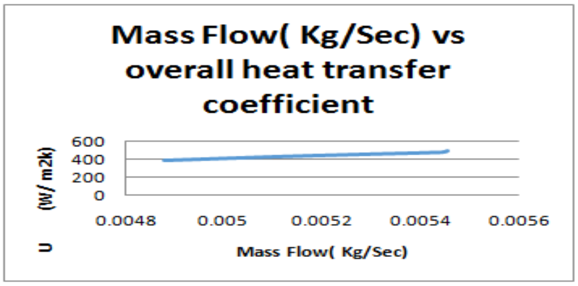

Fig.7.Mass flow rate versus U (for parallel flow)

From this graph of mass flow rate versus U, the overall heat transfer coefficient of heat exchanger first remains constant and then goes on increasing with increase in mass flow rate.

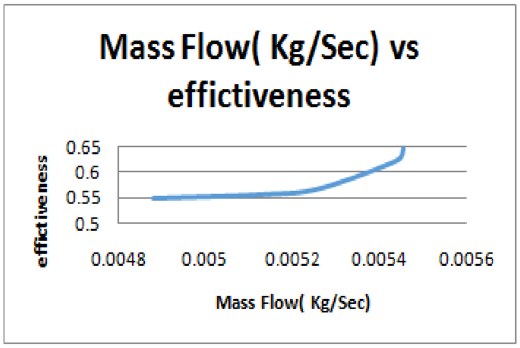

Fig.8. Mass flow rate versus Effectiveness (for parallel flow)

From this graph of mass flow rate versusEffectiveness for parallel flow, the effectiveness of heat exchanger goes on increasing with increasein mass flow rate in parallel flow condition.

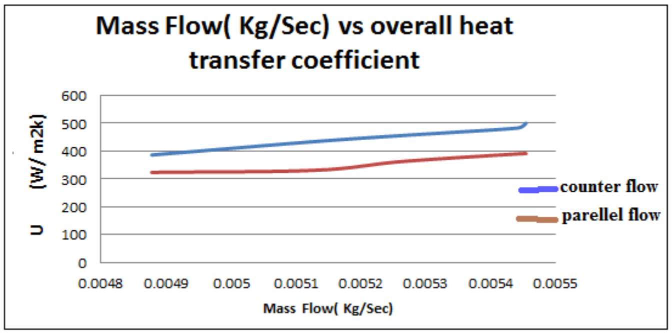

Fig.9. Mass flow rate versus overall heat transfer coeficient U W/ m^2k

From this graph of mass flow rate versus U, the overall heat transfer coefficient of heat exchanger for counter flow and parellel flow is first remains constant and then goes on increasing with increase in mass flow rate. For counter flow overall heat transfer coeficient is more than parellel flow cofiguration .

VI. CONCLUSION

1. Overall heat transfer coefficient of heat exchanger goes on increasing with increase in mass flow rate up to 22.61 % for counter flow configuration and for parallel flow the overall heat transfer coefficient of heat exchanger goes on increasing up to 17.19 %
2. Effectiveness of heat exchanger goes on increasing with increase in mass flow rate up to 15.98 % for counter flow configuration and for parallel flow Effectiveness of heat exchanger goes on increasing up to 15 %
3. LMTD of heat exchanger goes on increasing with increase in mass flow rate up to 18.19 % for counter flow configuration and for parallel flow LMTD of heat exchanger goes on increasing up to 12.16 %
4. For counter flow overall heat transfer coefficient is more than parallel flow configuration.

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