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Comparative Study of Floating Head Multi Stream Heat Exchanger With Shell and Tube Heat Exchanger

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Abstract— **Heat transfer between two streams is common, well established and perfectly commercialized. Normally, the exchanger that is intended for this purpose is shell and tube but in some industrial applications we have more than one reactant which are to be preheated or pre-cooled for chemical reaction and same as post heating and post cooling required of multiple streams at same or different temperatures, Problem that is associated with the shell and tube heat exchanger is that it can't handle the multiple streams and for handling multiple streams we required more number of exchangers due to which capital cost increases and required more care of handling. To overcome this problem, we need more than one heat sinks with one or more than one heat source that will minimize the covered volume per unit heat transfer area, the number of unit operation, operation time, man power and the capital cost with increasing thermal efficiency and heat utilization so to overcome this problem we need to move towards multi stream heat exchanger. Multi stream heat exchanger is opening of a new class of heat transfer equipment which deals more than two different streams for heat exchange. Such a way number of units can be reduced, which minimize time and space. With a little bit increase in complexity the operational cost will decrease and improve the thermal efficiency of heat transfer equipment, which minimize thermal losses and maximize the heat utilization. The present study involves the Comparative Study of Floating Head (Triple pipe) Multi Stream Heat Exchanger with Shell & Tube Heat Exchanger, where we calculate experimentally the heat duties of both fluids, effectiveness and fractional heat transfer and compare the results to prove that by using The Floating Head Multi-Stream (Triple Pipe) Heat Exchanger number of units can be reduced, which minimize operational cost, time, space and thermal efficiency will be improved.**

Keywords: *- Comparative Study, Floating Head Multi Stream Heat Exchanger, Shell and Tube Heat Exchanger*

I INTRODUCTION

A heat exchanger is a device used for the transference of heat between two fluids while transferring the heat it should be at maximum rate and minimal capital cost [1]. The fluid may be single phase or two phase it depends upon the type of exchanger and its form it may be separated or in contact. A heat exchanger is used for the transmission of enthalpy between the fluids. Heat exchanger have been classified in several ways, according to heat transfer mechanism, according to the flow arrangements i.e. parallel, counter or cross flow [2-4]. Transference of heat between two streams is very common and most of the industries are operating such equipment there has been a frequent approach towards improvement in heat exchanger devices so that lesser heat energy would be lost to the surrounding and achieve a high efficient and effective heat exchanger device. So, there is a need to move towards multi stream heat exchanger to ensure heat transfer among three different streams in minimum time, minimum volume and minimum cost to resolve this problem a new class of heat exchanger was introduced i.e. Floating head Multi-Stream heat exchanger [5].

Floating head Multi-Stream heat exchanger is a different class of heat exchangers designed to improve thermal efficiency of exchangers by minimizing time and space. The ability of an exchanger to either heat more than one cold source simultaneously or cool more than one hot source simultaneously makes it effective for use in industries. Multi stream exchanger is a revolutionary addition in heat transfer equipment because they can operate with great efficiency under the right configuration. With the little bit increase in complexity the operational cost will decrease and improve the thermal efficiency of heat transfer equipment, which minimize the thermal losses and maximize the heat utilization which directly decrease the equipment size and capital cost.

II MATERIALS AND METHODS

The Real Idea

"Emerging more than one heat sinks with one or more than one heat source will minimize the covered volume per unit heat transfer area, number of unit operation, operation time, man power and capital cost with increasing thermal efficiency and heat utilization"

2.1-Methodology

For Comparative Study of Floating Head Multi Stream Heat Exchanger with Shell and Tube Heat Exchanger following methodology was adopted.

- Sizing of Floating Head Multi Stream Heat Exchanger
- Experimentation on Floating Head Multi Stream Heat Exchanger
- Experimentation on Shell and Tube Heat Exchanger
- Comparative Study of Floating Head Multi Stream (Triple Pipe) Heat Exchanger and Shell and Tube Heat Exchanger.

2.2-Sizing of Floating Head Multi Stream Heat Exchanger

For Comparative Study a Floating Head Multi Stream Heat Exchanger is needed. Thus, Floating head Multi-Stream heat exchangers having the equal heat transfer area of shell and tube heat exchanger is constructed by three concentric tubes of the same length which are connected with floating head. Floating head Multi-Stream heat exchangers have some advantages as in the floating head it is easy to remove tubes for cleaning and this floating head exchanger have the advantage of low maintenance cost. For this purpose, the whole apparatus is specially designed.

Table 1 Parameters of Floating Head Multi-stream heat Exchanger

Name	Symbol	Dimensions
Inner tube diameter	D_i	0.012m
Length of inner tube	L_i	0.55m
Central tube diameter	D_c	0.122m
Length of central tube	L_c	0.461m
Outer tube diameter	D_o	0.088m
Length of outer tube	L_o	0.457m
Head diameter	H_d	0.025m
Length of head	H_l	0.100m

It is expected that the Floating Head Multi Stream Heat Exchanger designed using UNITY introduce a new class of Multi Stream heat exchangers.

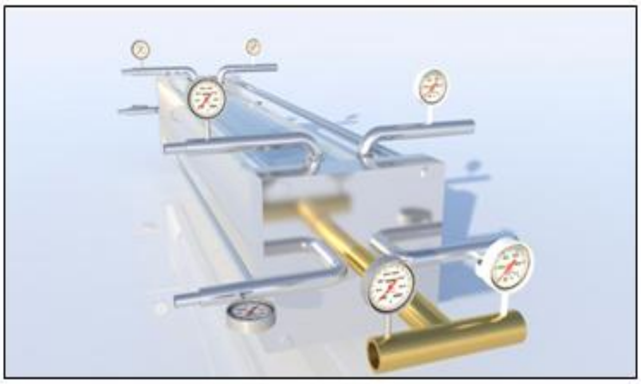

Figure 1: Floating Head Multi Stream Heat Exchanger

Figure 2: Floating Head Multi Stream Heat Exchanger

Figure 3: Side View of Floating Head Multi Stream Heat Exchanger

2.3-Shell and Tube Heat Exchanger:

Table 2 – Parameters of Shell and Tube exchanger

Name	Dimensions
1-shell, 2-tube pass	L=20-inch, D=4 inch
No. of tubes	18
Tube length	20 inches
Tube dia (inside)	9 mm
Tube dia (outside)	12 mm
Tube thickness	12mm

Comparative study is carried out by keeping hot water flow rate constant and cold-water flow at same value, the flow

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rates of hot & cold water are controlled by using the rotameters in both exchangers.

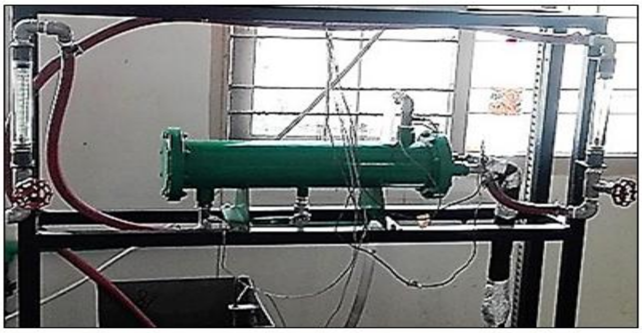

Figure 4: Shell and Tube Heat Exchanger

- For hot water flow rates are selected as 1.2 LPM, 3.5 LPM, 6.6 LPM, 8.5 LPM
- For cold water flow rates are also kept 1.2 LPM, 3.5 LPM, 6.6 LPM, 8.5 LPM.
- After achieving steady state various temperature are recorded and according to the various procedures effectiveness Qc and Qh utilization of heat is calculated.

2.4-Consideration for the Experimentation

The major consideration made for the experimentation of multi stream heat exchanger is as follows:

- Two cold fluids flow through the inner and outer tube in same direction.
- Hot water flow through the Central tube
- Heat transfer from hot fluid to cold fluid streams takes place without phase transformation.
- Heat exchangers are well insulated against atmosphere
- One hot stream is entering at same flow rate as we kept for cold stream
- There is no fouling in heat exchangers
- Flow is continuous, uniform and steady.

III RESULTS AND DISCUSSION

3.1-Comparison of Heat Duty (Qh) at Various Flow Rates

Table 3- Data for Heat Duty (Qh)

Flow rate (LPM)	Qh (KW) (Multi Stream)	Qh(KW) Shell and tube
1.2	0.8360	0.7524
3.5	1.72634	1.2331
6.6	3.6784	3.2186
8.5	4.73733	4.14517

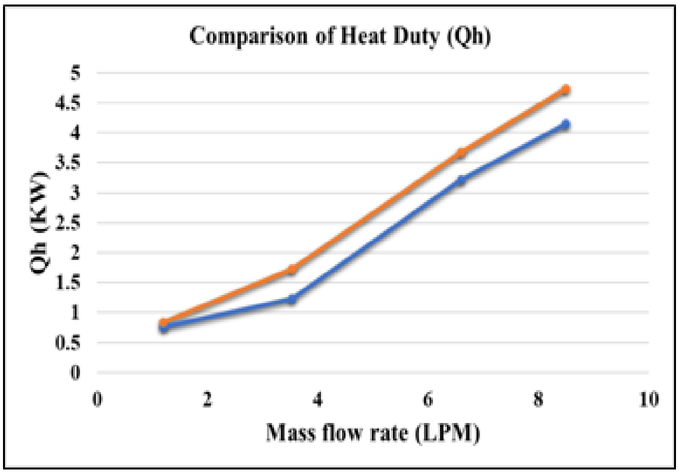

Figure 5: Comparison of heat duty (Qh)

We see that at same flow rate of cold and hot fluid for both shell and tube heat exchanger and floating head multi stream heat exchanger amount of the heat given by the hot fluid i.e. Qh is better in Floating head multi stream heat exchanger than shell and tube heat exchanger.

3.2- Comparison of Heat Duty (Qc) at Various Flow Rates

Table 4- Data for Heat Duty (QC)

Flow rate (LPM)	Qc (KW) (Multi Stream)	Qc (KW) (Shell and Tube)
1.2	0.5852	0.5016
3.5	1.5048	1.0032
6.6	3.2186	2.7588
8.5	3.58226	3.553

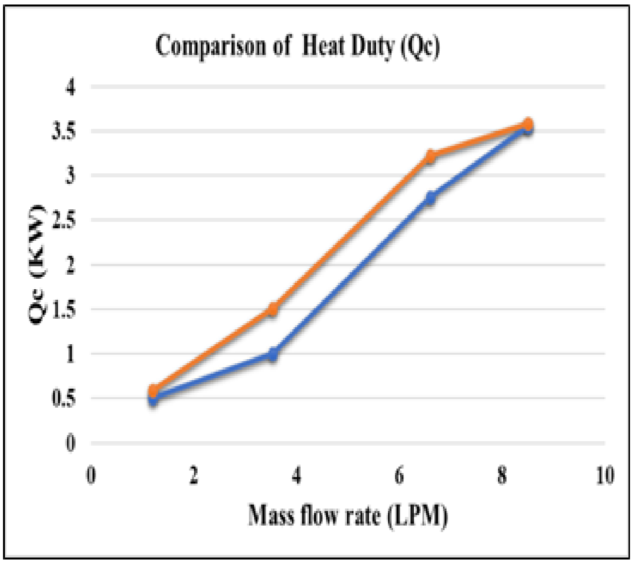

Figure 6: Comparison of heat duty (Qc)

We see that at same flow rate of cold and hot fluid for both shell and tube heat exchanger and floating head multi stream heat exchanger amount of the heat achieved by the cold fluid from the hot fluid i.e. Qc is better in Floating head multi stream heat exchanger than shell and tube heat exchanger.

3.3-Comparison of Effectiveness

Table 5- Data for Effectiveness

Flow rate (LPM)	Effectiveness (Multi Stream)	Effectiveness (Shell and tube)
1.2	0.3437	0.266667
3.5	0.3333	0.32
6.6	0.2535	0.222222
8.5	0.2333	0.230769

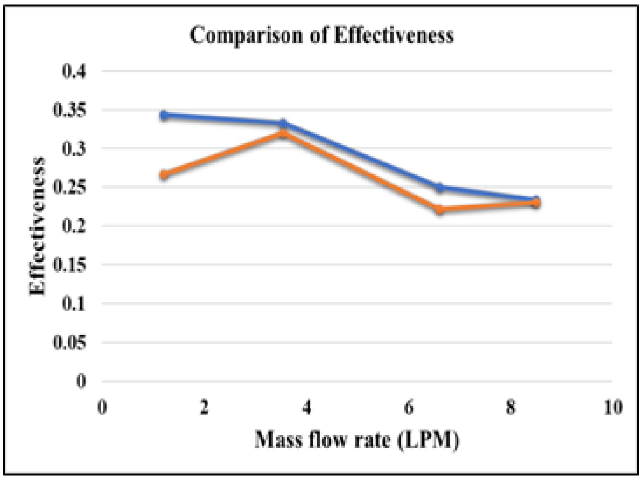

Figure 7: Comparison of Effectiveness

3.4-Comparison of Heat Utilization

Table 6- Data for Heat Utilization

Flow rate (LPM)	Heat utilization (Multi Stream)	Heat utilization (Shell and tube)
1.2	0.7005	0.666667
3.5	0.8716	0.813559
6.6	0.8750	0.857143
8.5	0.7562	0.857143

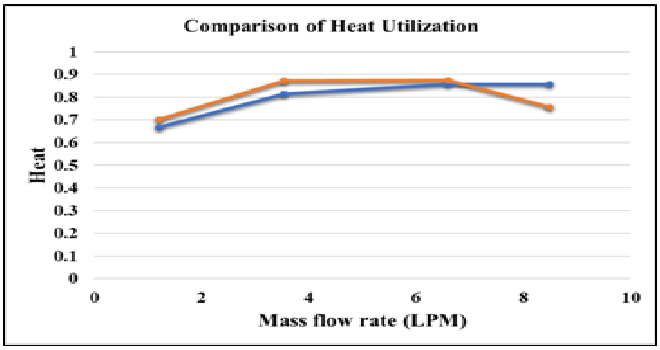

Figure 8: Comparison of Heat Utilization

IV CONCLUSION

Thus, Floating Head Multi-Stream Heat Exchanger provide good heat transfer, the effectiveness of Floating Head Multi-Stream Heat Exchanger is better than the shell and tube heat exchanger. Fractional heat transfers of Floating Head Multi-Stream Heat Exchanger are greater than the shell and tube heat exchanger. Heat duties (Qh and Qc) is better. Another aspect is that at low flow rates of the hot and cold fluid there is higher value of the effectiveness this is mainly because of the at low flow rates the they remain for more time in heat exchanger and exchange of the heat becomes higher. So, by result we can see that the heat duties, thermal efficiency, effectiveness and fractional heat transfer is better due to which number of units, operational cost, time, space reduces so we can say that is a compact version of heat exchanger where we can deal with more than two different streams for heat Exchange.

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