Experimental Investigation to enhance the Performance of Heat Exchanger used in Silica Plant to Recovery Waste Heat

Sahil A. Patel[1] Arvind K. Gothwal[2] Maheshkumar J. Patel[3]
[1]M. E. Student [2]Assistant Professor [3]Engineer
[1,2]Merchant Engineering College, Gujarat, India [3]Government of Gujarat

Abstract— Hot water plays an import role in modem life. The consumption of hot water represents a significant part of the nation's energy consumption. One way of reducing the energy Consumption involved, and hence the cost of that energy, is to reclaim heat from the waste Warm water that is discharged to the sewer each day. The potential for economic waste water heat recovery depends on both the quantity available and whether the quality fits the requirement of the heating load. To recover heat from waste Water in residential and commercial buildings is hard to achieve in quality because of its low temperature range. Nevertheless, efforts to recycle this waste energy could result in Significant energy savings. The objective of this research was to develop a multiple heat exchanger for a waste water heat recovery system. The advantage of the system proposed in this work is that it not only provides useful energy transfer during simultaneous flow of cold supply and warm drain water but also has the ability to store recovered energy at the hot water for later use. While this concept is not new, the design of the heat exchanger proposed for the present study is significantly different from those used previously. Measurements of hot water usage and waste water temperature and flow rates were obtained for a potential application of the proposed exchanger.

Keywords: Plate and Frame Heat Exchanger, Shell and Tube heat Exchanger, Flow Control Valve, Temperature Sensor, Temperature Measure Meter, Plain Tube

I. INTRODUCTION

Heat exchangers are devices that can be used to transfer heat from a fluid stream (liquid or gas) to another fluid at different temperatures. Heat exchangers are such devices in which the exchange of energy takes place between two fluids at different temperature. A heat exchanger utilizes the fact that, where ever there is a temperature difference, flow of energy occurs. So, that heat will flow from higher temperature heat reservoir to the lower temperature heat reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them.

The energy flowing in a heat exchanger may be either sensible energy or latent heat of flowing fluids. The fluid which gives its energy to another fluid is known as hot fluid. The fluid which receives energy from another fluid is known as cold fluid. It is but obvious that, temperature of hot fluid decrease whiles the temperature of cold fluid increase in heat exchanger. The purpose of heat exchanger is either to heat or cool the desired fluid.

II. PROBLEM DEFINITION

To the better heat transfer and make heat exchanger more compact, we have to increase the heat transfer rate of the heat exchanger. For this augmentation technique can be used.

From the previous research study it has been observed that augmentation techniques used to increase the heat transfer rate of the heat exchanger. So many works has been done by this method and most of the methods they are using Plate and Frame Heat Exchanger, Shell and shell Tube Heat Exchanger, Plain tube ,Temperature Sensor, Temperature Measure Meter, Flow control valve using the measure the flow verifying the cold water Temperature.

III. OBJECTIVE & GOAL

- To Increase the water temperature by two Heat Exchanger as it directly improves the performance of heat exchanger.
- If we are the enter the waste hot water in plate heat exchanger and after the shell and tube heat exchanger and the exit the waste hot water in shell and tube heat exchanger and passing the cold fresh water enter the shell and tube heat exchanger and after the enter the plate heat exchanger and the fresh hot water temperature is 65℃ the achieve the goal is completed.
- Augmentation Technique of heat exchanger using the water temperature increases heat exchangers are most valuable engineering devices in many industries since the efficiency and economy of the process largely depends on the performance of the heat exchangers. So, high performances of heat exchangers are required by the industry. Improvement in performance may result in reduction in size of heat exchanger. Alternatively high performance heat exchangers of a fixed size can give an increased heat transfer rate; it might also give a decrease in temperature difference between the process fluids enabling efficient utilization of thermodynamic availability. The vital present day need to conserve energy and materials has resulted in huge growth in research and development to improve heat transfer equipment design.
- Both commercial and domestic hot water systems consume a lot of energy heating water. This is due in part to the high heat capacity of water and the amount of energy required to change the temperature of water. In domestic settings, most hot water systems use a hot water heater that may be electric or gas powered to heat water from a water Source such as a municipal water system or well water. Other systems may use boilers.
- Commercial hot water systems may also use boi ers or hot water heaters. The hot water is used to provide hot water for showers tubs, sinks, dishwashers, laundry or any other use for hot water. Many uses for hot water are high consumption uses. As a result, a large amount of the water, while still hot, goes down the drain. One classical example of this is a shower. After the water from a

shower goes down the drain, often it will still contain a large amount of heat, which is wasted as the waste water goes through a water disposal system such as a septic system or municipal sewer. And the project is in the used in shell and tube heat exchanger, plate and frame heat exchanger using the increases the water temperature.

IV. LITERATURE SURVEY

This study has analyzed the daily and seasonal variability of flow and temperature of wastewater in the sewer system of Bologna. This kind of study can be useful in the design of structures for the conveyance or the treatment of wastewater, or in the design of heat recovery systems that need the knowledge of temperature time patterns.

In particular, it has been shown that the flow trend varies according to the size of the sewer system with peak values of the daily coefficient between 1.50 and 1.25 from about 12,000 to over 400,000 inhabitants. The minimum values of the daily coefficient are included between 0.25 and 0.50.

The wastewater temperature shows instead a more limited daily variability with variation coefficients between 0.90 and 1.05. The seasonal variation is more pronounced, in fact there are daily average temperatures of the sewage of about 20.9ºC in October to about 13.5ºC in December. These oscillations, as already mentioned, are however more damped than those of air. In fact, it is possible to observe that while the air temperature undergoes a reduction of the average daily value of about 21.4ºC, the wastewater, in the same period, changes only by 7.4 ºC.

In the second part of the paper an example of dimensioning of a system that exploits wastewater has been executed and the values that the various parameters may assume in this type of calculation have been highlighted.

A. Schematic Diagram of Experimental Setup

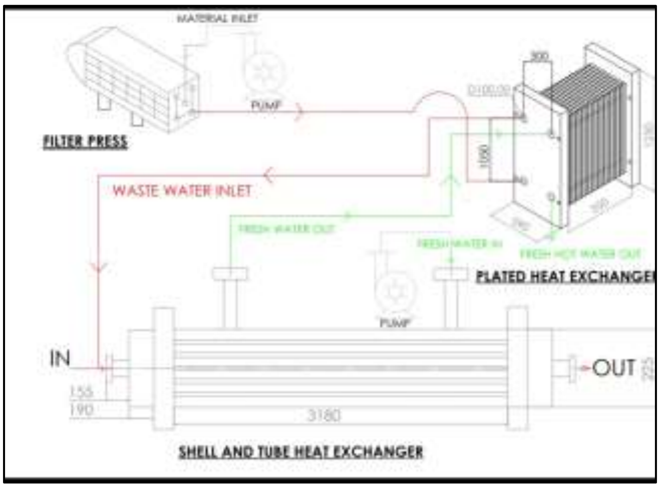


Fig. 1: The photograph of Experimental setup

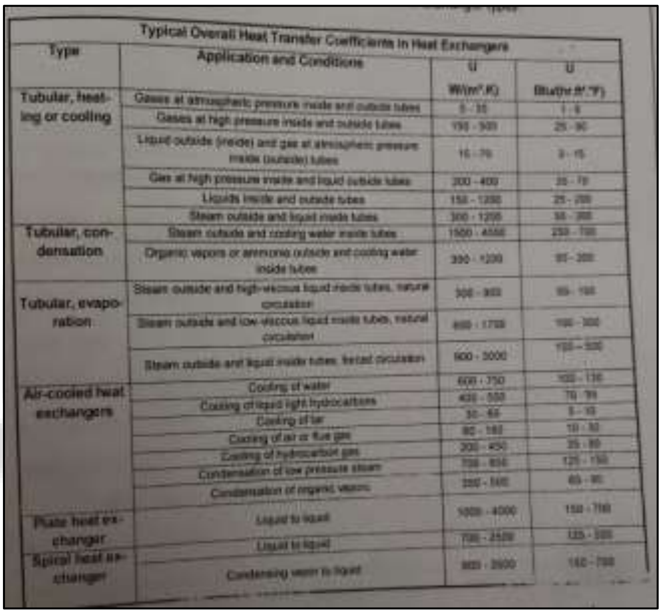
In this setup different two type of heat exchanger is one type of plated type heat exchanger and second type of shell and tube heat exchanger. The first effluent hot water is passed away from plated type heat exchanger and second time passed away from shell and tube heat exchanger and the other waste water is by sewage. And the fresh cold water is passed from shell and tube heat exchanger and second time passed away from plated heat exchanger and fresh hot water is fall in tank of water.

1) *Waste Heat Recovery*
   T_1 = Inlet Fluid Temperature
   t_2 = Fresh hot water (fluid) Temperature
   T_2= Waste (outlet) effluent water Temperature
   t_1= Cold fresh water
2) *Heat Transfer Rate*
   $Q = m \times C_p \times (T_2 - T_1)$
3) *Log Mean Temperature Difference*

$$\Delta T_m = \frac{(T1-t2)-(T1-t2)}{\ln\left(\frac{(T1-t2)}{(T1-t2)}\right)}$$

4) *Heat Transfer Area*

$$A = \frac{Q}{U \times \Delta \mathrm{Tm}}$$



Typical Overall Heat Transfer Coefficients in Heat Exchangers

Type	Application and Conditions	U W/(m².K)	U Btu/(hr ft² °F)
Tubular, heating or cooling	Gases at atmospheric pressure inside and outside tubes	5 - 35	1 - 6
	Gases at high pressure inside and outside tubes	150 - 500	25 - 90
	Liquid outside (inside) and gas at atmospheric pressure inside (outside) tubes	15 - 70	3 - 15
	Gas at high pressure inside and liquid outside tubes	200 - 400	35 - 70
	Liquids inside and outside tubes	150 - 1200	25 - 200
	Steam outside and liquid inside tubes	300 - 1200	50 - 200
Tubular, condensation	Steam outside and cooling water inside tubes	1500 - 4000	250 - 700
	Organic vapors or ammonia outside and cooling water inside tubes	300 - 1200	50 - 200
Tubular, evaporation	Steam outside and high-viscous liquid inside tubes, natural circulation	300 - 900	50 - 150
	Steam outside and low-viscous liquid inside tubes, natural circulation	600 - 1700	100 - 300
	Steam outside and liquid inside tubes, forced circulation	900 - 3000	150 - 500
Air-cooled heat exchangers	Cooling of water	600 - 750	100 - 130
	Cooling of liquid light hydrocarbons	400 - 550	70 - 95
	Cooling of tar	30 - 60	5 - 10
	Cooling of air or flue gas	60 - 180	10 - 30
	Cooling of hydrocarbon gas	200 - 450	35 - 80
	Condensation of low pressure steam	700 - 850	125 - 150
	Condensation of organic vapors	350 - 500	65 - 90
Plate heat exchanger	Liquid to liquid	1000 - 4000	150 - 700
Spiral heat exchanger	Liquid to liquid	700 - 2500	125 - 500
	Condensing vapor to liquid	900 - 3500	150 - 700

Fig. 2: Overall Heat Transfer Coefficient in Heat Exchanger

V. RESULT & DISCUSSION

A. TIME SAVING:

Saving Hours
= Before Installation (Dec-2019) – After Installation (Jan-2020)
= 7.56 – 4.87
= 2.69hrs/day

B. SAVING OF BOILER FEEDING WATER:

Saving Feeding Water
= Before Installation (Dec-2019)-After Installation (Jan-2020)
= 40733 - 30474
= 10259 l/day

C. SAVING OF COAL:

Coal saving
= Before Installation (Dec-2019)-After Installation (Jan-2020)
= 8732-6429

= 2303 kg coal/day

VI. CONCLUSION

This experimental work has been done to increase the heat transfer coefficient of counter flow heat exchanger. From the above experiments, we observe the before installation design and after installation design is the before installation design cost is very high and the after installation design cost is very low.

Plate heat exchanger is high heat transfer area and high heat transfer co-efficient.

Increasing the number of plate the area of heat exchange can be increased.

The most suitable type of heat exchangers for lower flow rates and heat sensitive substance.

Lower capital cost, reduced plant size and increase safety are typical of the benefits arising from the use of plate heat exchangers.

Plate heat exchangers can replace some normal size heat exchangers bringing advantages and performance.

REFERENCES

[1] B. Orr a, A. Akbarzadeh a , M. Mochizuki b , R. Singh b " A review of car waste heat recovery systems utilizing thermoelectric generators and heat pipes" Applied Thermal Energy 101 (2016) 490–495
[2] Heat recovery from urban wastewater: Analysis of the variability Of flow rate and temperature "Sara Simona Cipolla, Marco Maglionico" Energy and Building 69 (2014)122-130
[3] Energy recovery from wastewater: Heat over organics "Xiaodi Hao, Ji Li, Mark C.M. van Loosdrecht, Han Jiang, Ranbin Liu" Water Reasearch 161 (2019) 74-77
[4] Sustainability Analysis for Wastewater Heat Recovery "Magnus arnell , Ulf Jeppsson, Emma Lundin" 2017 CODEN:LUTEDX/(TEIE-7267)/1-41/92017)
[5] Heat recovery from wastewater: Assessing the potential in northern areas " Eva Pongrácz" August 2013
[6] Energy Recovery from Wastewater: A Study on Heating and Cooling of a Multipurpose Building with Sewage-Reclaimed Heat Energy "Daniele Cecconet , Jakub Racˇek , Arianna Callegari and Petr Hlavínek" Sustainability 2020, 12, 116; doi:10.3390/su12010116
[7] Efficient drain water heat recovery in horizontal domestic shower drains " Aonghus McNabola, Killian Shields" Energy and Building 59 (2013)44-49
[8] Heat transfer analysis of a shell and tube heat exchanger operated with graphene nanofluids " Mohammad Fares , Mohammad AL-Mayyahi , Mohammed AL-Saad" Case studies in Thermal Engineering 18 (2020) 100 584
[9] Heat and mass transfer a practical approach, third edition by Yunus A. Cengel, Tata McGraw-Hill publication.

NOMENCLATURE

Q = Heat Transfer Rate
M = Mass
C_p = Specific Heat
ΔT= Temperature Difference
˚C = Celsius
˚F = Ferranti
L = Length
B = Width
lb. = Pound
Btu = British thermal unit
U = Overall Heat Transfer
A = Heat Transfer Area
ΔT_m= Log Mean Temperature Difference