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Energy Conservation and Optimization in Condensate Splitter Plant

Eid M. Al-Mutairi*, Husamelden Elkawad

Department of Chemical Engineering
King Fahd University of Petrolem Minerals, Saudi Arabia, Dhahran, 31261
mutairi@kfupm.edu.sa

In this work, energy integration of a heat exchanger network (HEN) of the Plant Refinery was carried out using the Pinch Analysis Technology through (Heat-int) software. From the operating data, the HEN data was extracted, then the heat exchanger network data were analysed through varying the Pinch temperature and the amount of hot and cold utilities were observed. Also the effects of Pinch temperature on the area of heat exchangers were done. The percentages of changing in hot and cold utilizes beside the area of heat exchangers were investigated and the percentages of utilities and area changing with Pinch temperature were done. The main problem of the exiting heat exchanger network came from cross Pinch temperature, seven heat exchangers with total energy of 183.1 MMBTU/h crosses the Pinch Point that violated the Pinch rules. Cross Pinch Point with different Pinch temperature was found to occur, so attention must be taken with these temperatures.
The area efficiency of the current heat exchangers is 0.397 comparing with the ideal area with the same amount of hot utility. Retrofitting of the current heat exchangers was done by replacing some heat exchangers and adding new units. The reduced in hot and cold utilities were 6.79% and 27.9% respectively with 10.6% decreases in the area.

1. Introduction

Pinch technology is a methodology derived from simple scientific principles, by which it is possible to design new plants with optimum energy and capital costs. Also it's used with existing processes to improve the performance.
The condensate splitter plant produced high quality of naphtha, stabilized naphtha, LPG, heavy naphtha, kerosene, light and heavy diesel and atmospheric gas oil (AGO) for domestic uses and exportation.
In this work we are going to extract and analyse the information data to find the quantities of hot and cold utilities required for the crude distillation unit (CDU) and then investigate the effects of changing the Pinch temperature on the current heat exchanger network (HEN) using Heat-int software.
The Pinch Analysis technique has been used globally to target hot and cold energy requirement for crude distillation units (CDU) specifically and for any distillation column – see (Ajay et al., 2010) for general heat integration of distillation columns and (Nakaiwa et al,, 2003) for internally heat integrated distillation columns. Al-Riyami (2001) studied the effects of changing the Pinch temperature of a fluid catalytic cracking plant on the hot and cold utilizes and the area of the heat exchanger networks. Ajao and Akande (2009) investigated the energy integration of the crude pre heat train of Kaduna refinery where they found out the optimum Pinch temperature for the pre-heat train using Pinch Analysis techniques. Salomeh (2008) used the Heat-Int software which is based on methods of Pinch Technology to design, optimize and improve the integrated heat exchanger network of crude oil preheating Process in distillation unit in Arak refinery.
Revamping projects using pinch design method were conducted for existing oil refineries to improve their operation and achieve more energy savings (Liebmann and Dhole, 1995). On the other hand, the stage model has been applied to many CDUs such as work of Promvitak et al. (2009).

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2. Process Description

The process consists of desalting units, stabilized feed and the crude distillation units as shown in the block diagram in figure (1).

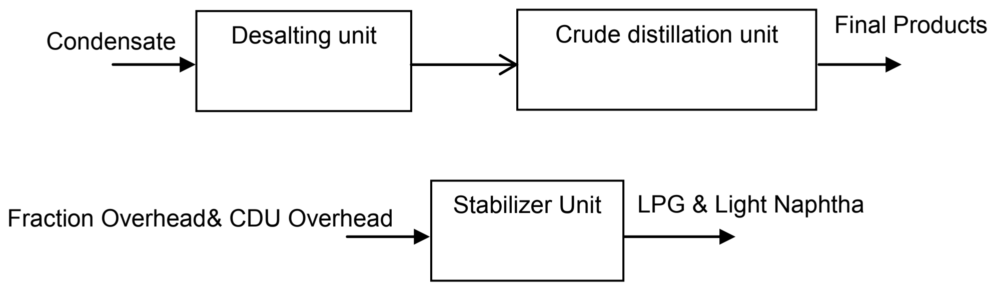

Figure 1: The Process Block Diagram

The splitter plant Refinery of the crude condensate produced a high quality of Naphtha, stabilized Naphtha, Liquefied Petroleum Gas (LPG), Heavy Naphtha, Kerosene, Light and Heavy diesel and atmospheric Gas Oil (AGO) for domestic uses and exporting.

First, the condensate crude from storage is preheated by the resulting products from the Crude Distillation Unit (CDU). The crude enters the desalting unit to remove the dissolved salts. Then it's entering the first distillation column (Flash Column). The bottom product from the flash columns heated in two furnaces using flue fuel gases then enters a second distillation column (CDU) .The top product is routed as feed to the condensate fractionator, while medium naphtha sent to the fractionator's top and light naphtha is routed to the fractionator's overhead/cold condensate exchanger. The distillations products are then used to pre-heat the feedstock before storing in the tanks or sends to exporting ports.

3. Data Extraction

The source temperature (T_s), target temperature (T_t), flow –rate and heat capacity and of each streams in the heat exchangers network were extracted. Also the areas of each heat exchanger in the network were extracted. The physical properties of the products from the crude distillation unit are shown in Table 1.

Table 1: The Physical Properties of the Crude Distillation Unit Products

No	Stream Name	Type	Density lb/ft^3	Viscosity CP	Specific gravity
1	Fractionators overhead	Cold	0.41	0.01	-
2.	Heavy naphtha	Cold	39	0.18	0.78
3.	Kerosene	Cold	38	0.17	0.81
4.	Light diesel	Cold	42	0.24	0.83
5.	Heavy diesel	Cold	42	0.24	0.85
6.	Fraction bottom	Cold	42	0.3	0.88
7.	Dirty was oil	Cold	40	0.21	0.87
8.	Factional feed	Hot	40	-	0.87
9.	Pre flash column overhead	Cold	0.63	0.01	-
10.	Hot crude	Hot	40	0.2	0.78
11.	Crude	Hot	48	0.84	0.78

4. Heat Exchangers Network

The process includes 128 streams with cold streams and hot streams. Also it's includes process to process heat exchangers and hot and cold utilities heat exchangers. The hot exchanger's utility uses steam and flue gases, and the cold utilities heat exchangers uses sea water and air as coolants. The energy consumptions of the exiting process are shown on the grand composite curve in Figure 2.

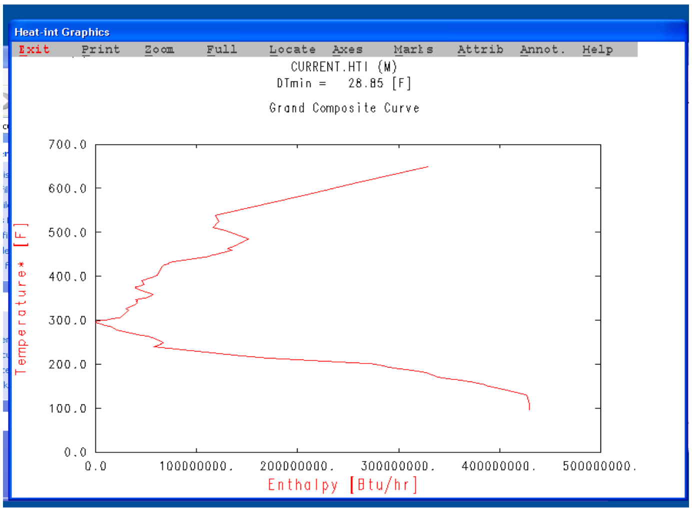

Figure 2: The Current Heat Exchanger Network Grand Composite Curve

From the diagram, the pinch temperature of the network is 28.85 ^{0}F, the amounts of the hot and cold utilities are 329 MMBTU/h and 429.8 MMBTU/h, the processes to processes heat exchanges is 893.2 MMBTU/h. The percentage of the energy consumptions are as shown in Table 2.

Table 2: Existing Utilities Percentage

Hot Utilities		Cold Utilities	
Flue Gases	99.998 %	Air Cooling	
150 Psig	0.001 %	Sea Water	0.178 %

4.1 Capital, Utilities and Total Cost of the Existing Heat Exchanger Network
The annual costs and the area of the existing network are shown in Table 3.

Table 3: The Current Heat Exchanger Network Data

Commodity	Amount	Unit
Hot Utility Cost	4.44	10^3 SAR/y
Cold Utility Cost	32,000	10^3 SAR/y
Total Utility Cost	32,000	10^3 SAR/y
Capital Cost	8,390	10^3 SAR/y
Total Network Cost	72,400	10^3 SAR/y
Total Area	432.0	10^3 ft^2
Process area	29.0	10^3 ft^2
Utility area	141.6	10^3 ft^2

Table 4: The Current Heat Exchanger Cross Pinch Energy

	Heat Exchanger No.	Energy (MMBTU/h)
1.	E231	1.70
2.	E101	47.9
3.	E201	9.27
4.	E222	22.4
5..	E350	27.2
6.	E211	144.4
7.	E241	12.2
	Total Energy	183.1

4.2 Analysing of Exiting Heat Exchanger Network

The existing network consists from 64 heat exchangers (process to process heat exchangers, two furnaces, three utilities and air fans cooling heat exchangers).Through analyzing the network to determine the inappropriate uses of energy consumption, either through crossing the Pinch temperature or inappropriate using for utilities. Table 4 shows the heat exchangers that violated the pinch rule.

4.3 Analysing the Heat Exchangers Network at Different Pinch Temperature

When applying different pinch temperatures for the exiting heat exchangers network, some heat exchangers violated one of the Pinch rules, heat transfer across Pinch. Table 5 below shows the numbers of heat exchangers that violated this rule and the amount of heat transfer through the Pinch. Figure 3 shows the loss of energy due to cross pinch temperature decreases as the pinch temperature increases.

Table 5: The Current Heat Exchanger Cross Pinch Energy

	Pinch temperature 10 ^oF	Pinch temperature 15 ^oF	Pinch temperature 20 ^oF
Heat Exchanger No.	Heat Transferred (MMBTU/h)	Heat Transferred (MMBTU/h)	Heat Transferred (MMBTU/h)
E101	3.23	12.80	16.14
E241	18.92	26.92	14.95
E211	4.32	3.34	2.35
E231	19.76	18.18	16.60
E222	7.48	7.48	7.48
E350	17.93	14.03	10.14
E202	0.293	2.35	1.76
Total	**103.61**	**84.14**	**69.43**

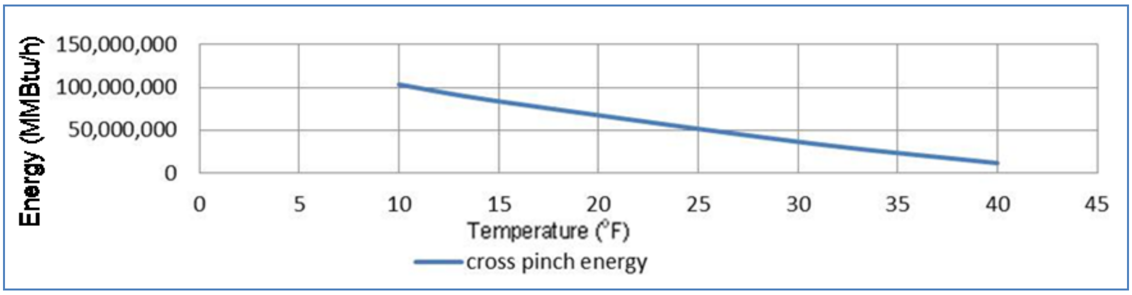

Figure 3: Cross Pinch Temperature Energy vs. different Pinch Temperatures

4.4 Determination of area efficiency for Retrofit Design

In retrofit design the area efficiency measures the performance of the exiting heat exchangers network with the ideal network. The closer the exiting heat exchangers area to the curve, best performance is given by the installed heat exchangers area. As shown in Figure 4, the efficiency of exiting heat exchangers area is 0.397, whereas the exiting and target areas for the energy recovery were 432,100 and 190,022 ft^2.

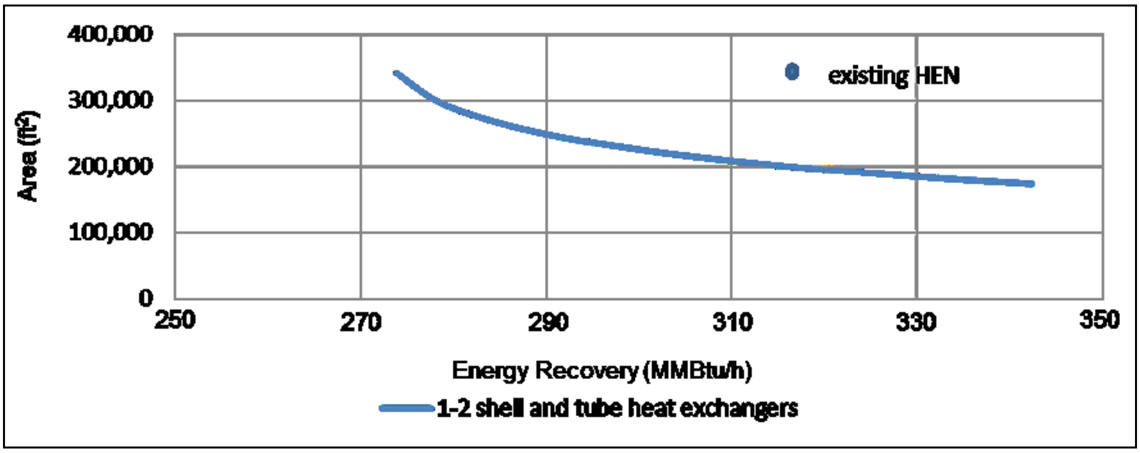

Figure 4: Energy Area Plot of the CDU Heat Exchangers Area vs. Energy Recovery

4.5 Adjusting the Current Heat Exchangers Network

When pinch analysis was applied to the current heat exchangers network, seven heat exchangers (E221, E241, E231, E101, E211, E222, E 350 and E202) crossed the pinch temperature as shown in Table 6. In order to avoid this situation, some arrangement for the network design is suggested as shown in Figure 5 in general manner. The solutions steps are:-

1. Determine the heat exchangers that cross the pinch temperature
2. Find out which stream violate the pinch rule
3. Move the exiting heat exchangers either below or above the pinch point, calculate the new are needed
4. Calculate the area for heat exchanger for the remaining energy recovery

After these steps, the expected energy saving were 6.79 % and 27.9 % for hot and cold utilities required.

Table 6: Heat Exchangers Crossing Pinch Temperature

Heat Exchanger	Stream Crossing Pinch Temperature	Energy Transferred (MMBtu/h)	
		Hot stream	Cold stream
1. E101	hot	42.8	
2. E241	hot + cold	17.4	10.7
3. E211	hot + cold	3.4	9.6
4. E231	hot	10.9	
5. E222	hot	4.0	
6. E350	hot	4.1	
7. E201	hot	4.6	

In this procedure, the old heat exchangers that violated the pinch rules will be replaced by efficient heat exchangers. The area will be reduced by 10.5 % in the new design.

Table 7: Heat Exchangers retrofit of current network

HE	Old Area ($10^3 ft^2$)	New Area ($10^3 ft^2$)
E101	5.50	6.01
E201	4.31	3.68
E231	5.14	4.08
E222	3.62	3.64
E241	9.21	3.08
E350	4.88	10.1
E211	7.40	5.22

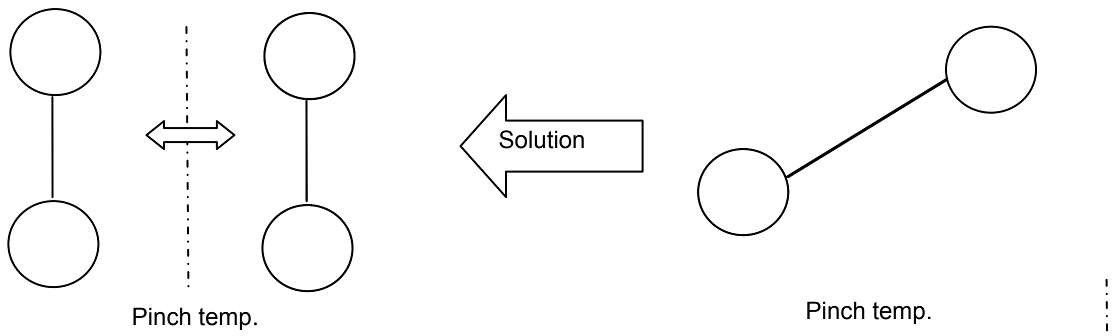

Figure 5: Suggested Solution for the Current Heat Exchangers Network

5. Conclusions

In conclusion, the Heat Integration of the heat exchanger network (HEN) of The Plant Refinery was carried out using the Pinch Analysis. It was found that retrofitting of the existing HEN can save a lot of energy. Modifications of current HEN were illustrated to show merits and benefits of integrating the energy within the plant.

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