Journal of Farayandno – Vol. 17 – No. 78 (2022): pp. 5-21

National Iranian Oil Refining and Distribution Company (NIORDC)

Journal of Farayandno

Research Paper

Application of Heat Integration in Reducing Energy Consumption in the Ethane Extraction Unit

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Received: 14 Feb 2022 **Accepted:** 22 Jun 2022

1. ABSTRACT

Heat integration using pinch analysis is one of the most important practical tools to achieve solutions that reduce energy consumption in operational units. Using this tool and determining the targeting, the conditions of the process in which the maximum potential of energy savings can be achieved are examined and evaluated. The method of this paper is analyzing the best energy saving opportunities using the pinch analysis method in the Ethane extraction unit of Pars Petrochemical Company. In this research, the approach based on the limitations of the industry and the application of solutions that impose the less modifications and investment costs on the industrial unit. Technical and operational studies show that the most opportunities for energy savings occur in heat integration between air coolers and heat exchangers. According to the two final solutions, 12,950 kW of energy will be saved annually in this unit.

Keywords: Reduction of energy consumption, Pinch technology, Heat integration, Ethane extraction

2. INTRODUCTION

In the corrective integration stage through pinch analysis, it is possible to approach a state of optimal heat load distribution by removing the loop and ΔT_{min} defect in the exchangers through the paths and reduce the investment costs. In this case, instead of removing the exchangers, they should relocate briefly. This work is done by increasing and decreasing the inlet and outlet temperature of the hot and cold flows related to the desired exchanger and is called "path analysis.

The main goal in this applied research is to optimize energy with minimal changes in the heat exchanger network, because there are many limitations to make changes in industries. [1]

3. MATERIALS AND METHODS

Pinch design method includes three main steps. In the first stage, which is thermodynamic analysis and known as thermal cascade calculation, the pinch temperature is determined. In the second stage, the necessary distributions of current and suitable structure are obtained in the vicinity of the pinch point. The third stage includes the combination of sub-grids on both sides of the pinch point with each other [2]. In the Pinch tool, the best process heat flows for heat exchange in the network of process heat exchangers are identified, and the required costs of the system to provide hot and cold services are checked by targeting the optimal consumption

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Please Cite This Article Using:
Mazidi Sharfabadi, M., Rezaei, E., Goodarzvand-Chegini, F., Jaberi, M., Fatollahzadeh Attar, R., Malekzadeh, Y., Agharazi, M., “Application of Heat Integration in Reducing Energy Consumption in the Ethane Extraction Unit”, Journal of Farayandno – Vol. 17 – No. 78, pp. 5-21, In Persian, (2022).

of each. After that, by using the data related to the economic parameters of the process and determining the optimal ΔT_{min}, the energy saving potentials are determined [3].
Among the energy saving potentials and taking into account the economic analysis, technical feasibility and implementation challenges of the selected solutions are presented along with their economic results.

3.1. Case study

The case study for the mentioned pinch analysis approach is the heat exchangers of Pars petrochemical ethane extraction unit.

a. Gathering information and economic parameters of the process

Table 1. Information on the process flows of the ethane extraction unit

Type	Name	phase	TS [°C]	TT [°C]	ΔH [kW]	[kW/ °C]$\dot{m}\ c_p$
Cold	E-0111 shell/ (Heater)	gas	15.43	220	2305	11.268
Hot	AE-1214 tube	gas	92.48	64.92	21592	783.453
Hot	E-1215/ (SW)	gas	64.92	40	19569	785.274
Hot	AE-2214 tube	gas	92.48	64.92	21592	783.453
Hot	E-2215/ (SW)	gas	64.92	40	19569	785.274
Cold	E-0311 tube/ (REB) LP	liquid	75.51	78	35821	14385.96
Hot	E-0312 tube/ (REF)	gas	-5.91	-8.42	23005	9165.338
Cold	E-0313 tube/ (REB) LP	liquid	108.88	111.9	29014	9607.271
Hot	E-0314 shell/ (SW)	gas	52.75	51.33	29674	20897.21
Hot	E-0316 tube/ (REF)	liquid	38	-9.73	4166	87.283
Hot	E-0317 tube/ (REF)	liquid	-9.73	-41	2482	79.373
Cold	E-0318 tube/ (REB) LP	liquid	113.45	117.78	8493	1961.431
Hot	E-0319 shell/ (SW)	gas	54.31	50.58	11895	3189.009
Hot	E-0321 tube/ (REF)	liquid	38	-4	1999	47.595
Cold	E-0413 tube/ (REB) LP	liquid	118.33	118.87	33846	62677.67
Cold	E-0511 shell/(Heater) HP	gas	17.28	285	6349	23.715
Hot	AE-0512 tube	gas	279.97	60	5292	24.058
Hot	AE-0513 tube	gas	148.64	65	2086	24.94
Hot	E-0711 tube/ (SW)	gas	90.55	51.44	74091	1894.426

Table 2. Required information and economic parameters

Firing Duty Cost, ($/1000m^3)	72.2	Power Cost ($/kWH)	0.05
Cooling water cost, ($/1000 gal)	0.2	Plant Life Time, (Y)	30
Interest Rate (I), (%)	18	Maximum Payback, (Y)	5
Investment Cost			
Area Capital Cost ($) =A+B(Area)^C			
Area Capital Factor A ($)	22400		
Area Capital Factor B	4430		
Area Capital Factor C	0.74		

b. Energy targeting and determination of maximum heat recovery

After all the information needed to perform the pinch analysis and related calculations were collected, these process and thermal data along with other characteristics of the process flows have been transferred to the reliable and commercial SuperTarget-Process software environment to start the pinch analysis on them.
According to the information related to the process flows in the existing heat exchange network, the existing value of ΔT_{min} is estimated to be around 176 °C.

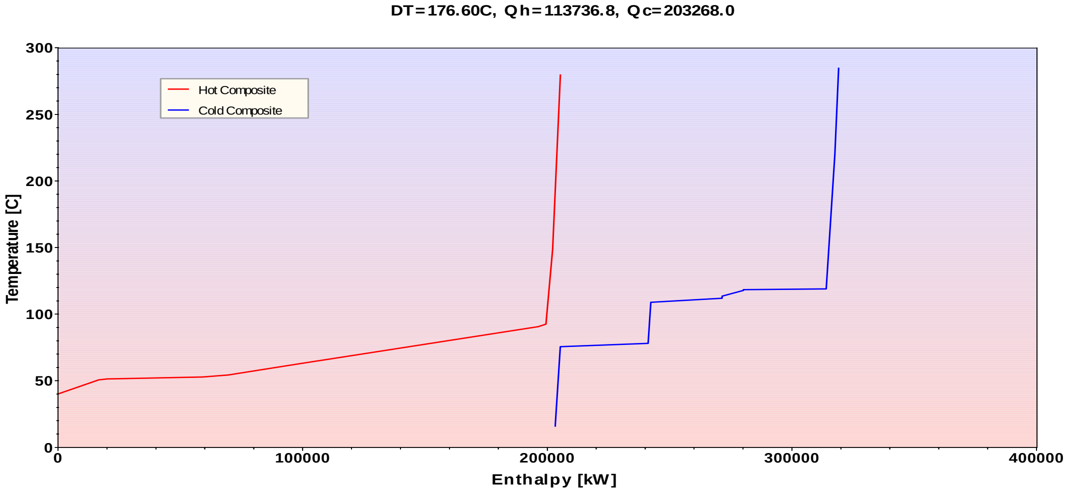

Figure 1. Composite curves of hot and cold stream of C_2 process unit

The targeting operation shows that the pinch point of the C_2 process is located at a temperature of 105.6 degrees Celsius. After finding the optimal ΔT_{min} and applying it to the heat exchange network, it can be clearly seen that the number of heat transfer exchangers is reduced from the pinch limit, and as a result, the values of utility services required by the process are also reduced.

4. RESULTS AND DISCUSSION

4.1. Review and analysis of suggestions for improvement of pinch analysis in ethane extraction unit

There are four energy saving potentials for the ethane extraction unit, which are:

a) Preheating of the regeneration gas entering the heater E-0511 by the flow entering the air cooler AE-0512,
b) Heating of the inlet flow to the E-0311 reboiler by the inlet flow to the AE-0512 air cooler,
c) Heating of the incoming flow to the E-0311 reboiler by the incoming flow to the AE-1214 air cooler
d) Heating the flow entering the reboiler E-0318 by the flow entering the air cooler AE-0512.

5. CONCLUSION

The investigations showed that the best available potentials are the preheating of heaters and reboilers by the heat of the incoming flow to the air coolers; Therefore, after performing pinch analysis in the network of heat exchangers and checking the two potentials confirmed from a technical and safety point of view (in the operation and risk study session) of heater and boiler preheating by the input flow from two air coolers, an economic analysis was carried out to check the effectiveness of the solution.

The results of economic calculations show that by implementing these two solutions, about 12950 kilowatts of energy will be saved throughout the year. The rate of investment return for the first solution is 0.6 years and for the second solution is 2.2 years, considering the appropriate IRR rate of both solutions compared to bank interest, both solutions can be considered suitable. By applying these two solutions, about 1.1 million dollars will be saved in energy consumption annually and 29484 tons of carbon dioxide pollutants will be emitted less.

6. ACKNOWLEDGEMENT

The authors are grateful for the financial support of Pars Petrochemical Company in carrying out this research in the form of the implementation of the research project under contract number 39-116/159952.

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