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Advanced Exergy Evaluation of an Integrated Separation Process with Optimized Refrigeration System

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Abstract: Advanced exergy analysis is a tool to split the exergy destruction of the system to achieve a better perspective about the potentials of a system for improvements. In addition, the component interactions and their exergy destruction dependency with the other equipment are investigated through the advanced exergy analysis. For this purpose, it divides the exergy destruction calculated by conventional exergy analysis, into endogenous/exogenous and unavoidable/avoidable. It can be concluded that the endogenous part has the most portion of exergy destruction in components. In other words, component interactions have minor effects on system irreversibility, except heat exchanger E-100, which is affected by the compressor's position. Sensitivity analysis is carried out to study the effect of some system parameters on compressor consumption power and total exergy destruction of the system. Results show that lowering the feed temperature and raising the feed pressure, decrease the compressor power, and higher pressure ratio decreases the total exergy destruction. Optimization is also carried out to reduce the power consumption of the compressor and propylene cooler.

Keywords: Exergy Analysis, Advances Exergy Analysis, Aspen HYSYS, Sensitivity Analysis, Optimization.

1. Introduction

With the increasing price of energy, shortage of resources and environmental issues, the necessity of energy consumption reduction as well as its optimization in energy relevant industries, has been revealed. Olefin plants are one of the industries with high energy demand. In regions with hot climates, consumed power in refrigeration systems is higher than other regions. Higher ambient temperature demands higher pressure ratio in compressors, which needs more power consumption at a constant flow rate. Ethylene and propylene, which are the raw material of most downstream petrochemical industries, are produced during thermal cracking of hydrocarbons in the furnaces of the olefin plant (Amidpour et al., 2015; Shirmohammadi, Ghorbani, Hamedi, Hamedi, & Romeo, 2015).

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This high demand for energy saving have led to the development of various techniques based on the second law of thermodynamics and, particularly, the concept of exergy. The goal of conventional exergy analysis is usually to determine the maximum performance of the system and identify the components with the most exergy destruction. Analyzing a complex plant, results the total plant irreversibility, distributed among the plant components (Kotas, 2013). There have been various studies on the exergy analysis of refrigeration systems (Ansari, Sayyaadi, & Amidpour, 2010; Bouaziz, Lounissi, Kairouani, & El Ganaoui, 2012; Sayyaadi & Saffari, 2010; Yataganbaba, Kilicarslan, & Kurtbaş, 2015).
This analysis alone doesn't have the necessary tools to determine the amount of exergy destruction that can be avoided, or the amount that is caused by contiguous components. This is done in the advanced exergetic analysis. In recent years, many studies included advanced exergetic analysis of the energy conversion systems (Anvari, Saray, & Bahlouli, 2015; Mehrpooya & Ansarinasab, 2015; Morosuk & Tsatsaronis, 2011; Petrakopoulou, Tsatsaronis, & Morosuk, 2015). Splitting the exergy destruction leads to deeper understanding of the exergy analysis results, therefore improves the preciseness of the analysis. The total exergy destruction produced within a component is not proprietary to the component (endogenous exergy destruction) but is also due to the inefficiencies of the other components (exogenous exergy destruction). The understanding of the various parts of Exergy Destruction for any component can help the designer on decision variables when optimizing the system.
The increase in complexity of plant related problems has developed the need for simulation programs. One of these simulators is Aspen HYSYS, which is a simulation software developed by Hyprotech Ltd. Apart from simulating a cycle, this program has many tools for analyzing the system, including case study, and optimizer. Case study is used to study the impact of different system parameters on each other (sensitivity analysis). Also optimizer is used to choose the best primary values to evaluate the minimum/maximum of the objective function. This program will be used for the optimization and sensitivity analysis of the cycle in this paper.

2. Process Description of Proposed Refrigeration Cycle of Tabriz Olefin Plant

This cycle is proposed and simulated in Aspen HYSYS to be replaced by a pure ethylene cycle of olefin plant in the Tabriz petrochemical complex. The cycle, developed and simulated in the paper, is based on presented cycle in (Ghorbani, Mafi, Shirmohammadi, Hamedi, & Amidpour, 2014). The purpose of the mixed refrigerant cycle shown in figure 1 is to provide the cooling required by Feed, and Reflux streams, which specifications are indicated in Table 1. In This cycle, mixed refrigerant is compressed by passing through mixed refrigerant compressor. Mixed refrigerant is then cooled and partially condensed below −32℃ by external propylene and water refrigeration cycle. Next, by using expanded cold streams potential, which are obtained from the top of the demethanizer tower, is sub cooled to −90℃ and then it is separated into two streams, namely 5 and 8. Stream 5 is then expanded in throttle valve in order to provide some cooling along with the potential streams. Stream 5 which is sub cooled by the multi stream heat exchanger, is divided into two streams, in order to supply required cooling for feed and recycle streams. One branch, after reducing its temperature and pressure in throttle valve, provides the cooling required for reducing the feed temperature from −94℃ to −98℃ , and the other does the same to reduce the reflux stream temperature from −94℃ to −97℃. Then the two streams are mixed again to reduce the initial feed temperature from −32℃ to −94℃. After that, the two initially separated streams, 5 and 8, are again mixed and go into the heater, in order to enter the compressor in the vapor state. Fig. 1

Table 1. Composition of feed and reflux streams

Substance	Feed	Reflux
-	Mole fraction	Mole fraction
Methane	0.3997	0.9508
Ethane	0.0336	0.0001
Propane	0.0016	0
Hydrogen	0.2480	0.0344
Propene	0.0239	0
Ethylene	0.2883	0.0110
CO	0.0049	0.0037

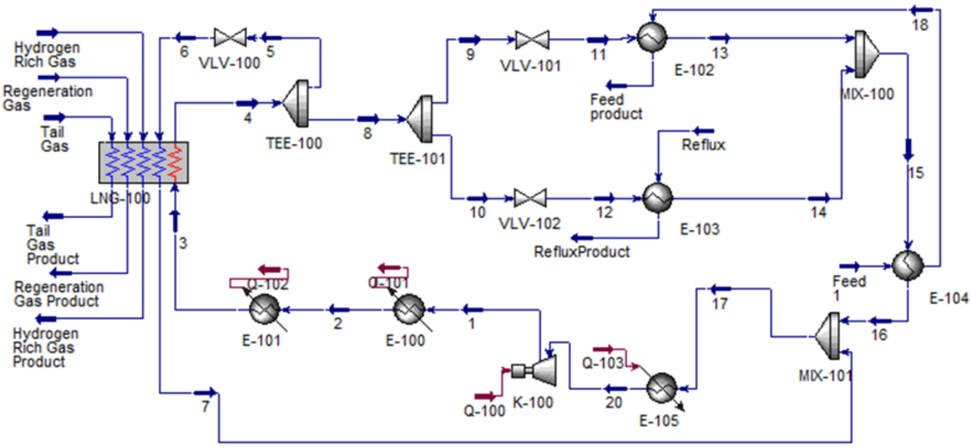

Figure 1. Schematic of mixed refrigeration cycle

3. Exergy Analysis

Exergy is a tool to measure distance of a system from reference state. The reference state is also called the dead state, which is in fact the same as surrounding (Vatani, Mehrpooya, & Palizdar, 2014). The total exergy of multi component streams is the sum of its two contributions: the exergy change due to chemical exergy, and physical exergy (Kotas, 2013): $e = e^{ph} + e^{ch}$ (1)

Physical exergy is calculated as follow (Kotas, 2013): $e^{ph} = h - h_0 - T_0(s - s_0)$ (2)

In which the subscript "0", refers to the ambient temperature and pressure. Thermodynamic data of process streams are presented in Table 2. In this paper, we use HYSYS v8.3 as our process simulation program, from which the total exergy (Physical exergy plus chemical exergy) can be obtained. So we only need to calculate physical exergy and obtain chemical exergy from total and physical exergy difference.

After the exergy values were calculated for all the streams, the fuel and product of the components was obtained, in order to calculate the exergetic efficiency of each component, which is calculated as follow (Kotas, 2013):

$$\varepsilon_i = \frac{\text{Product}}{\text{Fuel}} \quad (3)$$

Table 2. Thermodynamic data of process streams

Stream	Physical exergy (kj/h)	Chemical exergy (kj/h)	Total exergy (kj/h)	Stream	Physical exergy (kj/h)	Chemical exergy (kj/h)	Total exergy (kj/h)
1	-281683633	296240331	14556698	16	-164409121	169641172	5232051
2	-282045845	296248193	14202348	17	-289472212	296216910	6744697.9
3	-279010000	296167627	17157627	18	-72255878	87021538.1	14765660
4	-272767831	296154931	23387100	20	-291646955	296197518	4550562.7
5	-116538578	126530978	9992400	Tail Gas	-8782593.7	9173828.2	391234.5
6	-118115858	126536726	8420868	Tail Gas Prod.	-8863422	9176114.5	312692.5
7	-124860040	126557234	1697194	Regeneration Gas	-48029342	50502925.6	2473583.2
8	-156229253	169623953	13394700	Regeneration Gas Prod.	-48478105	50509329.6	2031224.8
9	-40885015	44389614.6	3504600	Hydrogen Rich Gas	-23930591	28060066.5	4129476
10	-115344239	125234339	9890100	Hydrogen Rich Gas Prod.	-24338168	28057910.5	3719742
11	-41438369	44391790.8	2953422	Feed	-76033032	87056036.6	11023005
12	-116905354	125240011	8334657	Feed Prod.	-71936532	87026712	15090180
13	-41789691	44395839.2	2606148	Reflux	-86711509	94204053.7	7492545
14	-117896500	125251138	7354638	Reflux Prod.	-85786595	94201117.9	8414523
15	-159686191	169651036	9964845	-			

3.1. Advanced Exergy Analysis

Irreversibility (exergy destruction) and exergy efficiencie (rational efficiency), which are calculated by exergy analysis, are used to perform the Advanced exergy analysis of the process components. Exergy destruction in a device not only depends on the performance, but also on the irreversibility of components which have correlations with it.

The Irreversibility of the components can be determined by Conventional exergy analysis; however, another tool is needed to discrete Irreversibility that occurs within the component, or the one that depends on the other components. Advanced exergetic analysis, divides the irreversibility of a device by two points of view: (1) origin of irreversibility and (2) potency to remove or decrease.

Based on the source of the exergy destruction, it can be separated into two parts; Endogenous exergy destruction and exogenous exergy destruction. The endogenous part occurs even if other components operate ideally, whereas the exogenous part is the result of the other parts not working ideally. The method to calculate endogenous part of the exergy destruction is developed by (Tsatsaronis & Morosuk, 2010). In this method a hybrid cycle is designed, in which every component except the component under analysis, is working ideally. Endogenous part of the exergy destruction is calculated through exergy analysis of this cycle. By calculating the endogenous exergy destruction, exogenous exergy destruction can be defined as below:

$$\dot{E}_{D,k}^{EX} = \dot{E}_{D,k} - \dot{E}_{D,k}^{EN} \quad (4)$$

Based on the potency to remove or decrease, the exergy destruction is separated into two other parts; Avoidable exergy destruction and Unavoidable exergy destruction. The unavoidable part is limited by technological restriction, while avoidable part can be reduced by improvement of the system. The term $\left(\frac{\dot{E}_D}{\dot{E}_P}\right)_k^{UN}$ is used to calculate unavoidable exergy destruction in kth component, which directed from the case where only unavoidable exergy destruction occurs. To calculate it, best conditions in which the component operates is assumed, including technological and financial. The theoretical and unavoidable conditions used in this paper are shown in table 3. Thus the unavoidable exergy is calculated by:

$$\dot{E}_{D,k}^{UN} = \dot{E}_{p,k}\left(\frac{\dot{E}_D}{\dot{E}_p}\right)_k^{UN} \quad (5)$$

In which $\dot{E}_{p,k}$ is exergy product of each component in the base case. Now the avoidable part can be calculated from difference of total exergy destruction and unavoidable exergy destruction as below:

$$\dot{E}_{D,k}^{AV} = \dot{E}_{D,k} - \dot{E}_{D,k}^{UN} \quad (6)$$

And $\dot{E}_{D,k}$ is exergy destruction of each component in the base case. After splitting the exergy destruction of each component into four categories, namely endogenous, exogenous, avoidable and unavoidable parts, the task left to be done will be to evaluate how different categories of the exergy destruction can be combined and used to provide meaningful information (Kelly, 2008). To make applicable results, avoidable and unavoidable exergy will be divided into two more section, endogenous and exogenous parts. Thus total exergy destruction is divided into four parts, namely Avoidable endogenous exergy destruction ($\dot{E}_{D,k}^{AV,EN}$), Avoidable exogenous exergy destruction ($\dot{E}_{D,k}^{AV,EX}$), Unavoidable endogenous exergy destruction ($\dot{E}_{D,k}^{UN,EN}$), and Unavoidable exogenous exergy destruction ($\dot{E}_{D,k}^{UN,EX}$).

The unavoidable endogenous exergy destruction ($\dot{E}_{D,k}^{AV,EN}$) within kth component is calculated as by:

$$\dot{E}_{D,k}^{UN,EN} = \dot{E}_{D,k}^{EN}\left(\frac{\dot{E}_D}{\dot{E}_p}\right)_k^{UN} \quad (8)$$

Now the other term can be calculated easily as below:

$$\dot{E}_{D,k}^{UN,EX} = \dot{E}_{D,k}^{UN} - \dot{E}_{D,k}^{UN,EN} \quad (9)$$

$$\dot{E}_{D,k}^{AV,EX} = \dot{E}_{D,k}^{EX} - \dot{E}_{D,k}^{UN,EX} \quad (10)$$

$$\dot{E}_{D,k}^{AV,EN} = \dot{E}_{D,k}^{EN} - \dot{E}_{D,k}^{UN,EN} \quad (11)$$

Table 3. Unavoidable, and theoretical operation conditions

Component	Unavoidable condition	Theoretical condition
Compressor_K-100	Isentropic efficiency=95%	Isentropic efficiency=100%
Heat exchangers	Minimum temperature approach=0.5 ℃	Minimum temperature approach=0 ℃
Pressure drop, Δp	0.5%	0
Throttle valves	Throttling	Isentropic expansion

4. Sensitivity Analysis

The objective of this section is to analyze the effect of the main variables on the system outcome. For this purpose Aspen HYSYS 8.3 is used. In its case study section, the effect of independent variables on dependent variables can be evaluated. The analysis is done by choosing four discrete states for the independent variables and producing the desired dependent variables. In this analysis, effects of pressure ratio on the total exergy destruction of the system, as well as the effects of feed temperature and pressure on the compressor power are studied.

5. Optimization

In this paper the goal is minimizing the total work consumed by the compressor and propylene cooler. For this purpose Aspen HYSYS 8.3 is used. There are three general steps to adjust the HYSYS optimizer. First, there are Primary variables, which are going to be manipulated in order to minimize the objective function. Pressure ratio is used as the primary variable in this work. Second step is to describe the objective function in a spreadsheet, and then put it as the parameter that is going to be minimized in the optimizer. And finally Constraint functions, which are defined in two ways, Inequality and equality. These parameters are usually discretionary variables to safeguard the heat exchanger's activity, and aren't necessary if after optimization, there isn't any malfunction in heat exchangers or other functions.

6. Results and Discussion

6.1. Results of Exergy Analysis

Although exergy destruction and exergy loss are two different concepts, but due to their similar effect, and adiabatic behavior assumption in most components, exergy loss disregarded. The Result of exergy analysis, excluding total exergy destruction and rational efficiency of each component is shown in table 4. Result of exergy destruction is illustrated in Fig. 2. As it can be seen, the compressor has the maximum amount of exergy destruction (2986677 kJ/h) and after that multi stream heat exchanger (LNG-100) has the most share of it. Other heat exchangers have relatively low exergy destruction, but regarding rational efficiency, they are not so far from the multi stream heat exchanger, which is the proof of its good design.

Table 4. Exergetic efficiency values of all components used in the refrigeration cycle

Equip. name	Fuel exergy	Product exergy	Prod Ex (Kj/h)	Fuel Ex(Kj/h)	ε_k %
Compressor_K-100	W	$\dot{m}_{20}(e_1 - e_{20})$	9963322.6	12950000	0.76
Cooler_E-100	$Q(1-\frac{T_0}{T})$	$\dot{m}_1(e_2 - e_1)$	362212.2	368918.3	0.98
Cooler_E-101	$Q(1-\frac{T_0}{T})$	$\dot{m}_2(e_3 - e_2)$	3035844.7	3166583.9	0.95
TEE-100	$\dot{m}_4(e_4)$	$\dot{m}_5(e_5) + \dot{m}_8(e_8)$	-272767831.4	-272767831.4	-
VLV-100	$\dot{m}_5(e_5)$	$\dot{m}_6(e_6)$	-118115858.1	-116538578.1	-
LNG-100	$\dot{m}_{Tail\ Gas}(e_{Tail\ Gas} - e_{Tail\ Gas\ Product}) + \dot{m}_{Regeneration\ Gas}(e_{Regeneration\ Gas\ Product} - e_{Regeneration\ Gas}) + \dot{m}_{Hydrogen\ Rich\ Gas}(e_{Hydrogen\ Rich\ Gas} - e_{Hydrogen\ Rich\ Gas\ Product}) + \dot{m}_6(e_6 - e_7)$	$\dot{m}_4(e_4 - e_3)$	6242168.8	7681350.8	0.81
TEE-101	$\dot{m}_8(e_8)$	$\dot{m}_9(e_9) + \dot{m}_{10}(e_{10})$	-156229253.3	-156229253.3	-
VLV-101	$\dot{m}_9(e_9)$	$\dot{m}_{11}(e_{11})$	-41438368.8	-40885014.6	-
VLV-102	$\dot{m}_{10}(e_{10})$	$\dot{m}_{12}(e_{12})$	-116905353.9	-115344238.6	-
Heat Exchanger_E-102	$\dot{m}_{11}(e_{11} - e_{13})$	$\dot{m}_{18}(e_{Feed\ Product} - e_{18})$	319346	351322.3	0.90
Heat Exchanger_E-103	$\dot{m}_{12}(e_{12} - e_{14})$	$\dot{m}_{Reflux}(e_{Reflux\ Product} - e_{Reflux})$	924913.7	991145.8	0.93
Heat Exchanger_E-104	$\dot{m}_{Reflux}(e_{Reflux\ Product} - e_{Reflux})$	$\dot{m}_{18}(e_{18} - e_{Feed})$	3777153.4	4722929.7	0.79
Mixer_MIX-100	$\dot{m}_{13}(e_{13}) + \dot{m}_{14}(e_{14})$	$\dot{m}_{15}(e_{15})$	-159686191	-159686191	-
Mixer_MIX-101	$\dot{m}_{16}(e_{16}) + \dot{m}_7(e_7)$	$\dot{m}_{17}(e_{17})$	-289472212.4	-289269161	-
Heater_E-105	$Q(1-\frac{T_0}{T})$	$\dot{m}_{17}(e_{20} - e_{17})$	2174742.8	2222702.6	0.97

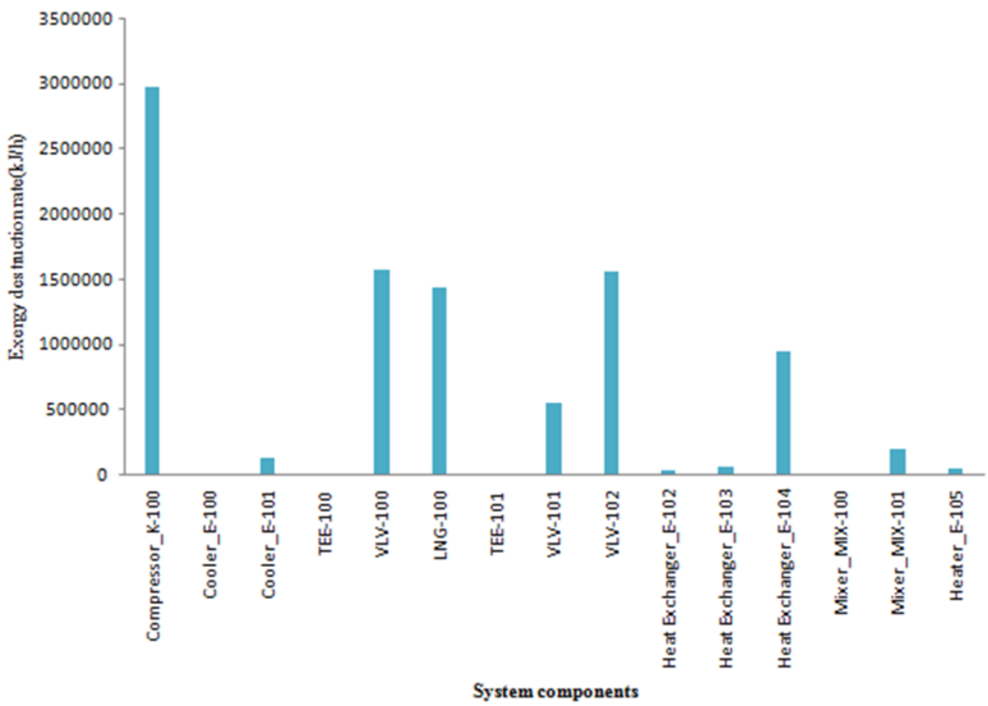

Figure 2. Exergy destruction for each system component

The reduction of exergy destruction in compressor is a direct effect of increasing the efficiency of the compressor, and the reduction of exergy destruction in water cooler, is a direct effect of outlet temperature of the compressor, so that less heat has to be removed from the cooler. Also the exergy destruction of the compressor is relevant to the ambient temperature; higher ambient temperature result in increasing exergy destruction, since the ratio of pressure in the compressor is the same in three states and with respect to reduction of density of input air, the compressor needs more consuming work and thus the exergy destruction of the compressor is increased (Mousafarash & Ahmadi, 2014).

7.2. Results of Advanced Exergy Analysis

Advanced exergy analysis of the process is shown in Table 5. As it was stated, endogenous exergy destruction was calculated by a hybrid cycle assumption, and exogenous part was calculated by equation 4. Also for calculating the unavoidable part of the exergy destruction, all components were assumed to be working in unavoidable condition.
Fig. 3 shows different parts of the total exergy destruction separately. As it is seen most of the exergy destruction in components, except water cooler E-100 is endogenous. The reason is irreversibility that occurs in the compressor, because inefficiency of the compressor affects the inlet stream of heat exchanger E-100. Table 5 also shows that a high portion of the exergy destruction produced by the compressor is avoidable, so by decreasing the exergy destruction in the compressor, better performance of the water cooler can be resulted. Higher amounts of endogenous exergy destruction reveal that interactions between components do not have a significant impact on the exergy destruction of the system.
Between heat exchangers multi stream heat exchanger LNG-100 has the most relative share of exogenous exergy destruction. Exogenous exergy destruction can be reduced by optimizing and improving process design. In general, except heat exchanger E-100, most of the exergy destruction produced in heat exchangers is unavoidable and not much can be done to reduce them. This matters in heat exchanger E-104 which has the most exergy destruction among the heat exchangers.
After a component with high avoidable exergy destruction was detected, the next step is to decrease the improper functioning. In Table 6 general strategies to confront this problem are explained. In the case of avoidable endogenous exergy destruction, replacing the components with more efficient one or redesigning it is recommended. For reducing the avoidable exogenous part, optimizing the process or increasing the efficiency of the other components can be used.

Table 5. Results of the advanced exergetic analysis of processes

Components	Exergy destruction categories (kj/h)							
	$\dot{E}^{EN}_{D,k}$	$\dot{E}^{EX}_{D,k}$	$\dot{E}^{UN}_{D,k}$	$\dot{E}^{AV}_{D,k}$	$\dot{E}^{AV,EN}_{D,k}$	$\dot{E}^{AV,EX}_{D,k}$	$\dot{E}^{UN,EN}_{D,k}$	$\dot{E}^{UN,EX}_{D,k}$
Compressor_K-100	2178439	808238	1902995	1083683	512819	570863	1665619	237374
Cooler_E-100	2774	3932.1	4346.5	2359.5	976	1383.5	1797.9	2548.5
Cooler_E-101	115784	14955	118397	12341	10929	1411.7	104854	13543
LNG-100	1134534	304648	1136075	303107	238945	64162	895588	240485
Heat Exchanger_E-102	29463	2513.3	30657	1319.1	1215.4	103.6	28247	2409.6
Heat Exchanger_E-103	60754	5478.	63819	2413	2213.4	199.5	58540	5278.4
Heat Exchanger_E-104	831876	113900	872522	73253	64431	8821.9	767444	105078
Heater_E-105	46688	1271.7	47844	115.4	112.7	3.06	46575	1268.7

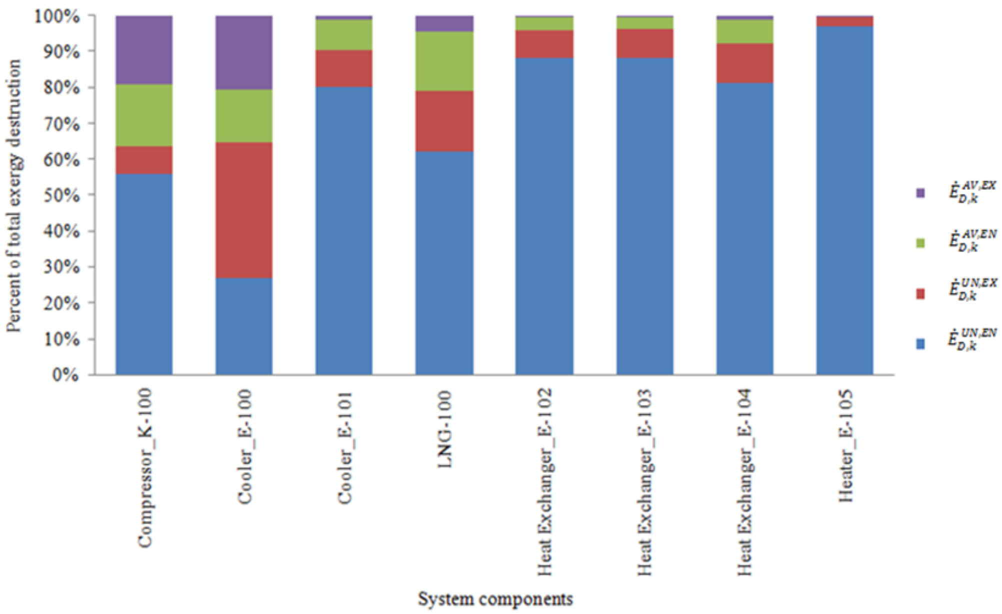

Figure 3. Splitting of component exergy destruction to endogenous/exogenous and avoidable/unavoidable parts

Table 6. Strategies for reducing avoidable exergy destruction

components	Exergy destruction categories (kj/h)				The part should be focused on	strategies to reduce exergy destruction		
	$\dot{E}_{D,k}$	$\dot{E}^{AV}_{D,k}$	$\dot{E}^{AV,EN}_{D,k}$	$\dot{E}^{AV,EX}_{D,k}$		Strategy A[a]	Strategy B[b]	Strategy C[c]
Compressor_K-100	2986677	1083683	512819	570863	EN./EX.	×	×	×
Cooler_E-100	6706.115	2359.5	976	1383.5	EN./EX.	×	×	
Cooler_E-101	130739.3	12341	10929	1411.7	EN.	×		
LNG-100	1439182	303107	238945	64162	EN./EX.	×	×	×
Heat Exchanger_E-102	31976.32	1319.1	1215.4	103.6	EN.	×		
Heat Exchanger_E-103	66232.08	2413	2213.4	199.5	EN.	×		
Heat Exchanger_E-104	945776.3	73253	64431	8821.9	EN./EX.	×	×	×
Heater_E-105	47959.78	115.4	112.7	3.06	EN.	×		

[a] Startegy A: Enhancing the efficiency of the kth component or replacing it with more efficient devices.
[b] Strategy B: Enhancing the efficiency of the other components.
[c] Strategy C: Optimization the system generally.

6.3. Sensitivity Analysis

Sensitivity analysis of the total exergy destruction to the pressure ratio of the compressor is shown in Fig. 4. Results show that, the total exergy destruction is decreased by increasing in the pressure ratio of the compressor.

Fig. 5 indicates the sensitivity of the compressor power to the temperature of the feed stream in 3480 kPa. The Result shows that increasing the feed temperature negatively effects the compressor power consumption. This study was done again in different pressures and results were illustrated in Fig. 6. The results show that reducing the feed pressure, increases the compressor power consumption.

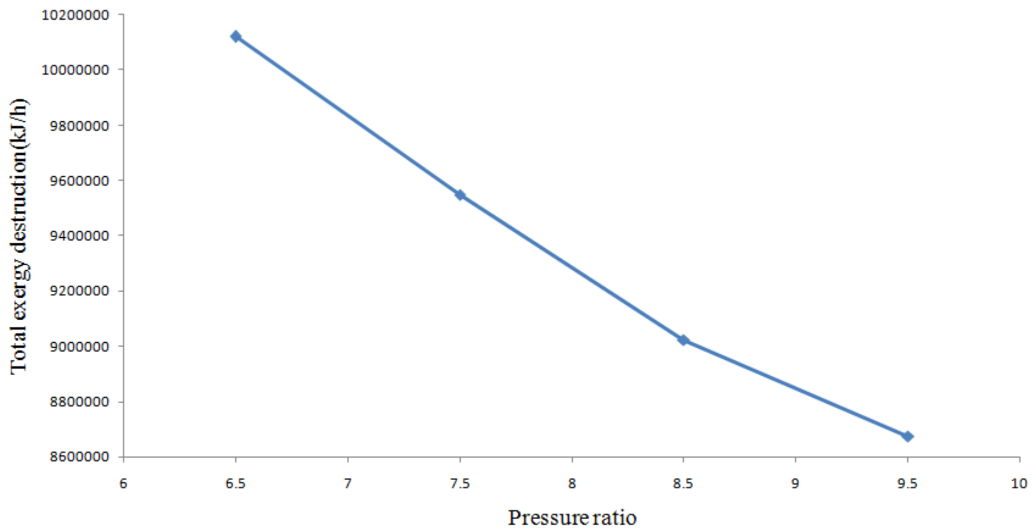

Figure 4. Sensitivity analysis of the total exergy destruction to the pressure ratio

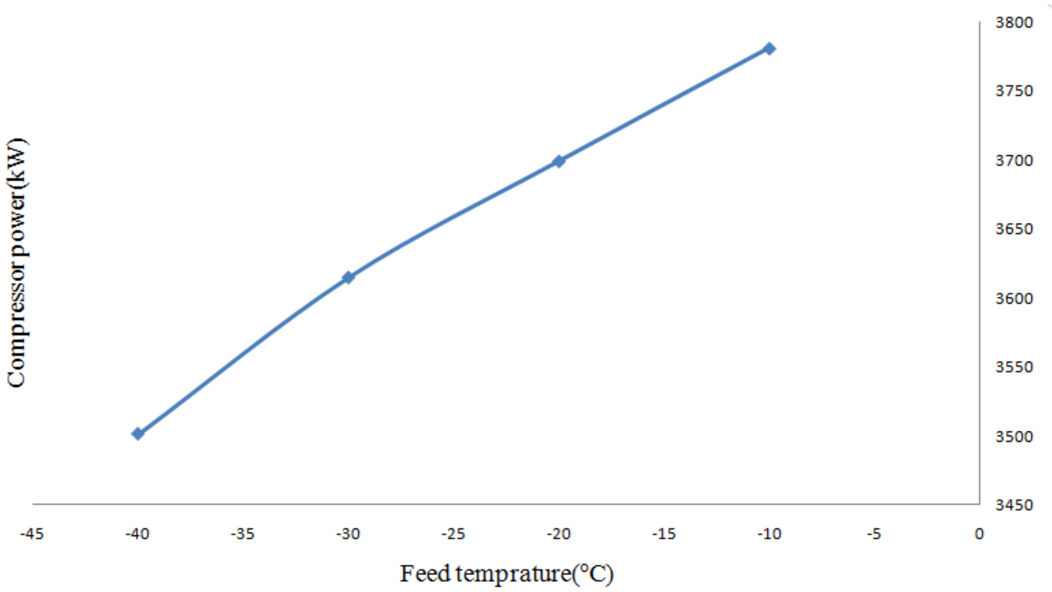

Figure 5. Sensitivity analysis of the compressor power to the feed temperature

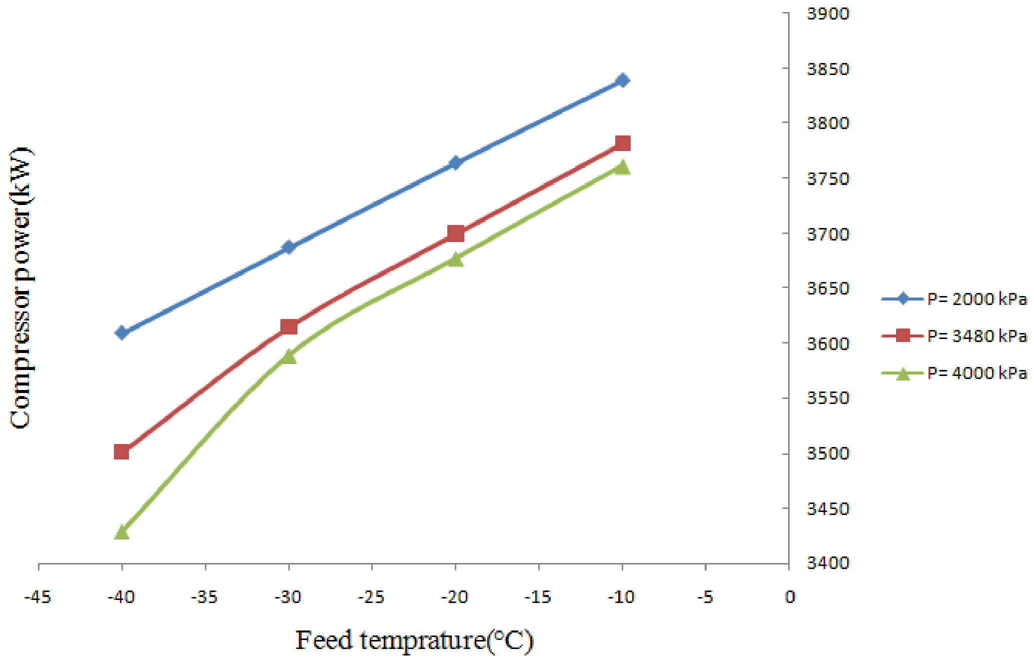

Figure 6. Sensitivity analysis of the compressor power to the feed temperature, in different pressures

6.4. Optimization Results

Optimization of the refrigeration cycle was achieved by using the primary variable (pressure ratio), while trying to minimize the objective function (work consumed by the compressor and propylene cooler). The results of optimization in addition to the base case condition are shown in Table 7.

It can be seen that as the result of this optimization, the pressure ratio of the compressor is increased. Thus, in addition to reducing the power consumed, based on the sensitivity analysis, the total exergy destruction is reduced too. Also the stream 17 that enters the heater E-105 is now vapor phase. So this component can be removed from the system, which is another parameter that reduces the power consumption.

Table 7. Results of optimization

Parameter	Base case	Optimized case
Pressure ratio	7.68	10.29
Pmax(kPa)	1383	1174
Pmin(kPa)	180	114
Compressor power(kW)	3598	2107
Propylene cooler power(kW)	6314	3857
Total power consumption(kW)	9912	5965

7. Conclusions

This paper presents results of applying exergy and thermoeconomic analysis in a refrigeration cycle for the Tabriz olefin plant. Equations of product and fuel for the system components such as compressors, heat exchangers, and expansion valves are developed, and the desired results are obtained. The exergy analysis results on the system shows that the compressor, throttle valves and the multi stream heat exchanger have the highest irreversibility. Most of the exergy destruction is generated endogenously. The high amount of exogenous exergy destruction in heat exchanger E-100 is also because of the compressor position. Sensitivity analysis shows the importance of feed temperature and pressure on the compressor consumption power. It is also antiseptic that in higher pressures, lowering the temperature can greatly decrease the compressor consumed power. It is also concluded that increasing in the pressure ratio leads to reducing in the total exergy destruction. Eventually, optimization of the system is carried out by Aspen HYSYS simulator, with manipulating the pressure ratios to gain the minimum work consumed by the compressor and propylene cooler. Results show that pressure ratio can increase by optimizing the consumption power, thus total exergy destruction can also be reduced.

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