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Optimization of Process Design and Operating Parameters of H2S Removal Unit to Reduce Lean Amine Inlet Temperature of Amine Contactor at Upstream Oil and Gas Subsidiary SI

Budi Sulistiyo Nugroho[1], Restu Ramadhani Pratama Putra[1], Aprilia Indah Mandaka[1], Genoveva Lestari Kulaleen[1] and Adhi Kurniawan[2]

[1]Oil and Gas Processing Engineering, Polytechnic of Energy and Mineral Akamigas
Gajah Mada Street No. 38, Cepu, Blora, Jawa Tengah, Indonesia.

[2]Upstream Oil and Gas Subsidiary SI
Maspion Industrial Estate Unit C, Beta Maspion Street, Manyar Sido Mukti, Gresik, Jawa Timur, Indonesia

Corresponding author: resturamadhani2002@gmail.com

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ABSTRACT - Upstream Oil and Gas Subsidiary SI is a natural gas processing company that operates an H2S removal unit to convert natural gas rich in CO_2 and H_2S into sweet gas. The main problem of this unit is the high temperature of Lean amine coming into contact with the amine contactor. The purpose of this study is to determine the factors of high lean amine temperatures, evaluate the Lean Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger performance, and ascertain the ideal operating parameters and process design configuration. The method used is simulation of H_2S removal unit with Aspen HYSYS, followed by comparative analysis between simulation data and equipment design data. The independent variables of this study include rebate duty, reflux ratio, and heat transfer area in the plate exchanger, with the primary dependent variable being lean amine temperature. The results showed that the high lean amine temperature was caused by a decrease in the performance of The Amine Regenerator Overhead Cooler and the Lean Amine Cooler, as seen from the UA and LMTD values of the simulation results which were smaller than the design. In contrast, the Plate Exchanger still functions well with a UA value that is more significant than the design. Optimization was carried out by adjusting the process criteria for design and operation of the H_2S removal unit. The optimized design involves bypass reflux from the Rich/Lean Amine Exchanger's regenerator for the rich amine stream and increasing the surface area of heat transmission of the Plate Exchanger to 62.17 m². The influential operating parameters are rebate duty, liquid flow rate to the mixer, and plate exchanger heat transfer surface area. Optimal operating conditions were achieved at a Reboiler duty of 1,642 kW, a liquid flow rate of 1.4 m³/h, reflux to Mixer ratio, and a heat transfer surface area of 62.17 m². In addition, it can be concluded that the optimization of process design and operating parameters successfully reduced the lean amine inlet temperature of the Amine Contactor.

Keywords: H2S removal unit, lean amine temperature, operating parameters, optimization, process design.

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INTRODUCTION

Upstream Oil and Gas Subsidiary SI is a company that processes natural gas. The company is located in an industrial area in Gresik, East Java. The company has a gas processing facility (Kurniawan 2024). This facility functions to process natural gas into sales gas (Mujiyanti 2018). Several process units are essential in the gas processing facility (Ministry of Education and Culture of the Republic of Indonesia, 2015). One of the process units that has a critical role in natural gas processing is the H_2S removal unit (Abdel-Aal 2003). This unit aims to process natural gas rich in converting acid gases like CO_2 and H_2S into pleasant gasses (Aziz et al. 2023). The H_2S removal unit at Upstream Oil and Gas Subsidiary SI uses an absorption-regeneration process with amine solvents. The operating conditions of the H_2S removal unit must always be maintained at certain limits (Fatimura & Fitriyanti 2018). This is because if the operating conditions of the H_2S removal unit are not maintained, it can interfere with the process in the H_2S removal unit (Sugihardjo 2022).

Based on available information, there is a problem in the H_2S removal unit. The problem is the high lean amine's temperature when it enters the amine contactor. Figure 1 shows that from January to February 2024, the lean amine's temperature as it enters the amine contactor was, on average, above 44°C. The highest temperature reached ± 46.5°C. Of course, this is not good for the absorption process. The optimal absorption process occurs at low temperatures and high pressure. In addition, the absorption process with amine solvents is chemical, and the reaction is exothermic (Sari 2017). The outlet of the Amine Contactor will experience an increase in temperature; if the outlet temperature of the Amine Contactor is too high, it can cause the evaporation of the water content in the amine solvent, so more make-up demine water is needed (Jones 2016). For the Amine Contactor outlet, the gas temperature graph can be seen in Figure 2.

It is evident from Figure 2 that the average gas outlet temperature is above 49°C, and the highest temperature is 53°C. This temperature can vaporize most of the water in the amine solvent, damaging the amine solvent's composition (Giffari et al. 2021). Therefore, the temperature must be maintained under certain conditions so that the absorption process can run well. In this case, the company has tried to reduce entering the Amine Contactor at the lean amine temperature by increasing the performance of the duty lean amine cooler. However, the efforts were unsuccessful because, based on information from the operator, the duty of the lean amine cooler has been maximized. So, it can be seen that there is a problem with the heat exchanger and more excellent performance in the H_2S removal unit.

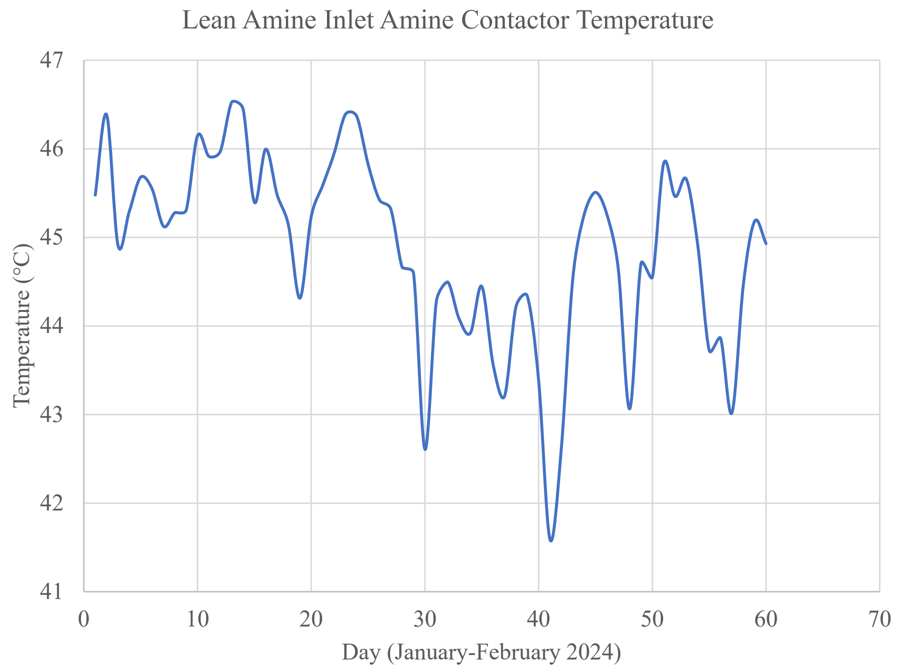

Figure 1
Temperature chart of lean amine inlet amine contactor (Primary Data 2024)

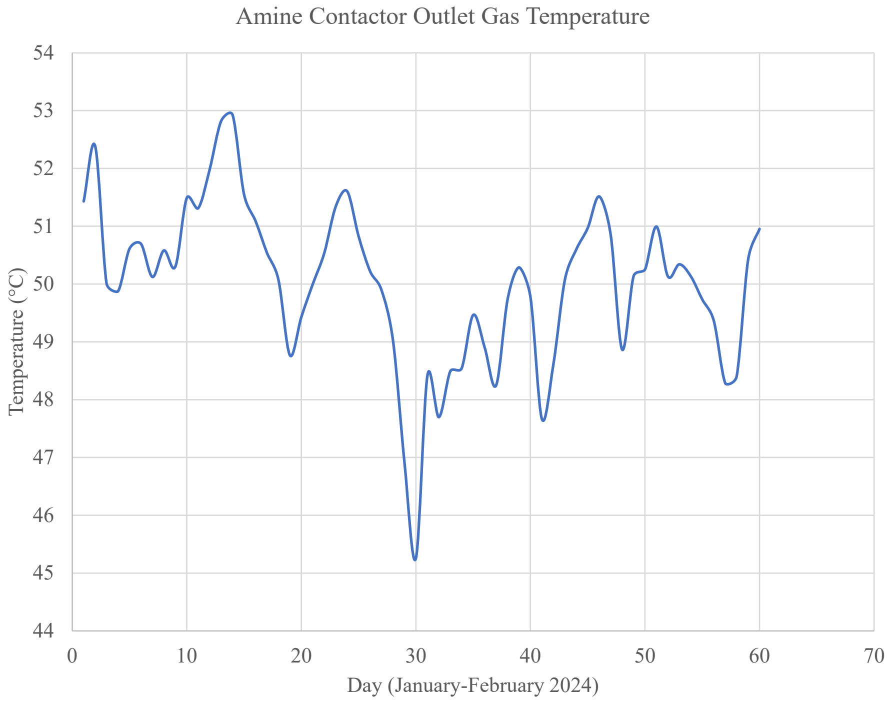

Figure 2
Amine contactor outlet gas temperature (Primary Data 2024)

To solve this problem, an evaluation is needed to determine the cause of high lean amine temperatures and optimize the ability to overcome them. If this is not done, it can disrupt the absorption process in the H_2S removal unit. Evaluation is aimed at the Amine Regenerator Overhead Cooler, Lean Amine Cooler, and Plate Exchanger to determine the performance of these tools. Furthermore, optimization was done by adjusting the process design and operating parameters in the H_2S removal unit. Thus, It is possible to lower the lean amine temperature so that the process in the H_2S removal unit can run well. Therefore, researchers are interested in optimizing this unit. The objectives of this study are to determine the cause of the high temperature of lean amine inlet Amine Contactor, evaluate the performance of the Lean Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger, get the proper process design configuration for the H_2S removal unit and determine the operating parameters that are influential in reducing determine the ideal operating conditions by measuring the temperature of the lean amine inlet Amine Contactor.

METHODOLOGY

The object of this study is the H_2S removal unit located in the Gas Processing Facility Upstream Oil and Gas Subsidiary SI. The leading process equipment reviewed are Amine Contactor, Amine Regenerator, Plate Exchanger, Lean Amine Cooler, and Amine Regenerator Overhead Cooler. The variables in this study include independent variables, namely rebate duty, reflux ratio, and heat transfer area in plate exchangers. The dependent variables are Regenerator top and bottom temperatures, flowrate and H_2S loading of lean amine out Regenerator, liquid flowrate from Amine Reflux Drum, Amine Regenerator Overhead Cooler duty, Regenerator inlet liquid temperature and volume, Mixer inlet liquid temperature and volume, lean amine out Plate Exchanger temperature, rich amine out Plate Exchanger temperature, Lean Amine Cooler duty, lean amine inlet Amine Contactor temperature, Amine Contactor out gas temperature and H_2S composition in sweet gas. For three months, this study was carried out, from January 2024 to March 2024. The objective function of this optimization is to lower the lean amine inlet Amine Contactor temperature. Meanwhile, the limiting function is the H_2S removal unit design operating condition data. The working method of this research as seen in Figure 3.

Based on Figure 3, this research begins with conducting literature studies, field observations, and collecting the necessary field data. Then, an overview of the H_2S removal unit was undertaken to determine

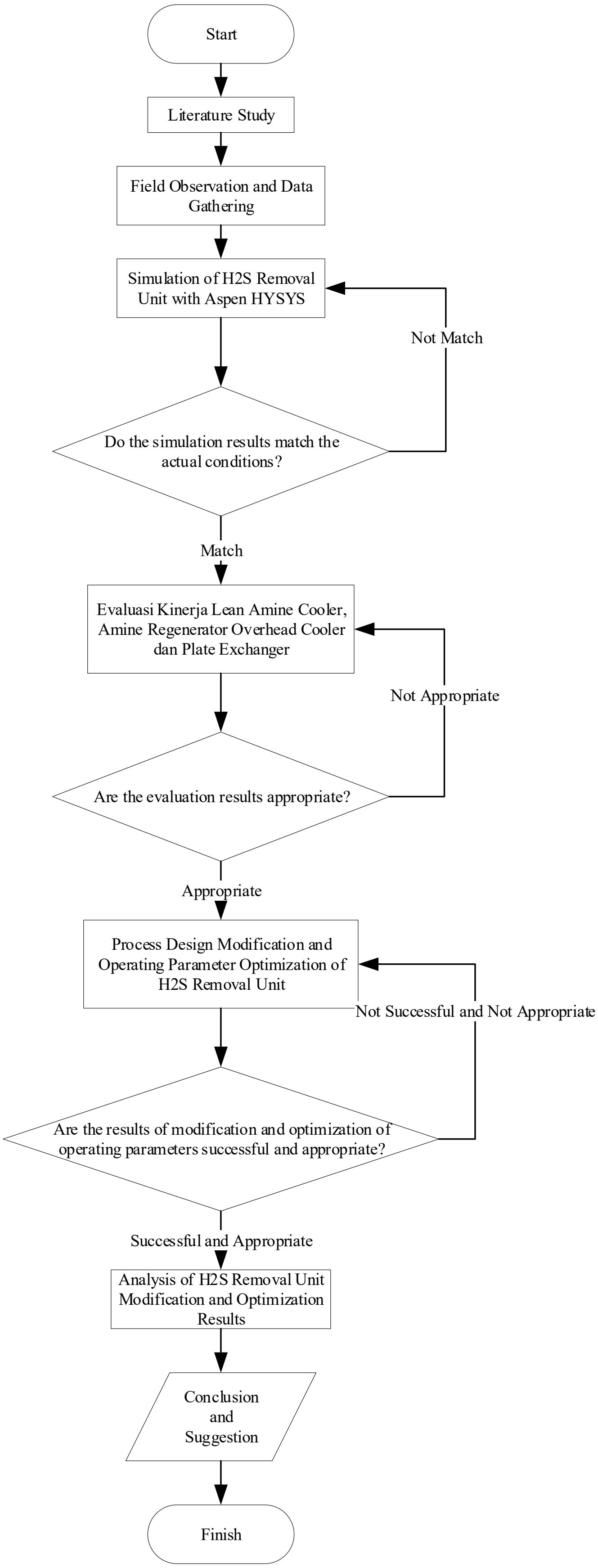

Figure 3
H_2S Removal unit optimization work method

the process in the unit. After that, a simulation of the H_2S removal unit is made where the simulation results must be close to the actual conditions (Michael 2021). If the results are appropriate, then proceed to evaluate the performance of the Lean Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger. The next step is to modify the process design and optimize the operating parameters of the H_2S removal unit. The optimum conditions are analyzed if the modification and optimization are successful and the results are appropriate (Fuqoha 2012). After that, conclusions and suggestions are drawn on the H_2S removal unit optimization results.

The analysis method used in this optimization simulates the H_2S removal unit, followed by an analysis by comparing the simulation data and the tool design data. H_2S removal unit simulation results must be close to actual conditions (Sopurta et al. 2014). This paper evaluates the performance of the Lean Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger. Then, after modifying and optimizing the H_2S removal unit, the optimum conditions will be found by comparing the optimization data with the design data. If an optimum condition has been found, the optimization is declared victorious and can be used as a recommendation for the company.

RESULT AND DISCUSSION

Brief Description of H_2S Removal Unit Process

The process gas enters Amine Contactor Inlet Knock-Out Drum 135-V-01 and will be separated between liquid hydrocarbons and hydrocarbon gas. Liquid goes to the Liquid Separator while hydrocarbon gas enters Amine Contactor 135-V-06, where an exothermic process occurs with a temperature of 28.5°C and a pressure of 45.7 bar. In the Amine Contactor, sweet gas goes to the Amine Overhead Gas Knock Drum 135-V-09 with a temperature of 44.5°C and a pressure of 45.7 bar. After that, sweet gas goes to the TEG Regeneration System. Liquid from Knock Drum enters Flash Drum Amine 135-V-10, and rich amine enters Flash Drum Amine 135-V-10 with a temperature of 30.9°C and a pressure of 6 bar (full vacuum).

After that, rich amine from Flash Drum enters Filter for Rich Amines 135-W-04. Then, from the Rich Amine Filter, enter the Concentrated Amine Exchanger 135-H-02 A/B. Then, it goes to Amine Regenerator 135-V-07 with a temperature of 94.7°C and a pressure of 0.8 bar (full vacuum). Then, the rich amine will be resolved into lean amine and acid gas. Acid gas goes from the Amine Regenerator Overhead Cooler (fin fan) to the drum of amine reflux 135-V-11. Amine is pumped to the Regenerator using the Reflux Pump, or amine enters the Amine Drainage Vessel 135-V-14. In the Regenerator, there is an Amine Reboiler. Lean amine is pumped to The Lean Amine Exchanger equipped with a heated lean amine pump. Lean amine goes to the Lean Amine Cooler, the Lean Amine Filter, The Amine Surge Vessel with the Carbon Filter. Then lean amine is pumped with a Lean Amine Pump 135-P-01 A/B with a pressure of 42.8 bar and a capacity of 45.5 m^3/hr.

H_2S Removal Unit Simulation

Several data sets must be used to simulate the H_2S removal unit using Aspen HYSYS. These data are operating condition data, natural gas and amine composition data, design data, and mechanical design data of the H_2S removal unit (Adikharisma 2014). These data will be input to Aspen HYSYS (Yaws 1999). Daily data is recapitulated for operating conditions from January 01, 2024, to February 29, 2024. Meanwhile, natural gas and amine composition data are monthly from January 2024 to February 2024. The following shows the average operating condition data and average natural gas and amine composition data used in the H_2S removal unit simulation:

Operating Condition Data

Table 1 above is the average data of H_2S removal unit operating conditions. The data will be used as input in the simulation of the H_2S removal unit in Aspen HYSYS.

Natural Gas Composition Data

Table 2 above shows the average natural gas composition data processed in the H_2S removal unit. The information will be entered into the simulation of the H_2S removal unit in Aspen HYSYS.

Amine Composition Data

Table 3 above shows the average amine composition data used in the H_2S removal unit. The information will be entered into the simulation of the H_2S removal unit in Aspen HYSYS.

A display of simulation results of the H_2S removal unit using Aspen HYSYS can be seen in Figure 4. The simulation results have described the actual situation (Rahman et al. 2022). This simulation can be used to evaluate the performance of the Lean

Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger and can be used as a basis for modifying the design of the H_2S removal unit.

Based on the simulation results, it can be seen that the process equipment related to the lean amine inlet Amine Contactor temperature is Plate Exchanger, Amine Regenerator Overhead Cooler, and Lean Amine Cooler. Researchers suspect there are problems with these three tools, so if the performance of these tools decreases, it can cause heat transfer in these tools not to run optimally. As a result, the lean amine temperature becomes higher. In addition, weather factors can affect the performance of the fin fan cooler, such as the air temperature around the Upstream Oil and Gas Subsidiary SI. A more detailed discussion related to the performance of the Plate Exchanger, The following discussion shows the Amine Regenerator Overhead Cooler and the Lean Amine Cooler.

Table 1
H_2S removal unit average operating condition data (Primary Data 2024)

Process Variable	Value	Unit
Amine Contactor lean amine inlet pressure	33.85	Barg
Amine Contactor lean amine inlet flow	24.91	m^3/hr
Flow sales gas	22.85	MMSCFD
GPF fuel gas flow	1.77	MMSCFD
LPGF fuel gas flow	1.23	MMSCFD
Amine Overhead Gas Knock-Out Drum outlet pressure	33.62	bag
Amine’s Flash Drum acid gas outlet pressure	4.02	barg
Amine Reflux Drum outlet pressure	0.39	barg
Amine lean flow inlet Vessel for Amine Surge	31	m^3/hr
Amine Reflux Drum's reflux flow	1.6	m^3/hr
Amine Reboiler heating medium flow	75.62	m^3/hr
Amine hot lean flow	25.56	m^3/hr
Temperature at Amine Contactor tray 4	47	°C
Temperature at Amine Contactor tray 9	52.99	°C
The temperature at the Amine Contactor's bottom	44.75	°C
Amine Contactor tray 1's temperature	49.53	°C
Temperature at Amine Contactor tray 12	48.88	°C
Amine Contactor inlet gas temperature	34.25	°C
Amine Contactor outlet gas temperature	50.02	°C
Amine Contactor inlet lean amine temperature	44.88	°C
Amine Regenerator outlet gas temperature	98.54	°C
Amine Regenerator bottom temperature	118.2	°C
Amine Flash Drum inlet temperature	41.93	°C
Amine outlet rich amine temperature Amine Exchanger	94.72	°C
Amine inlet temperature Amine Regenerator	91.01	°C
The temperature at Amine Regenerator trays 7 & 8	111.18	°C
Temperature at Amine Regenerator tray 15 & 16	118.01	°C
Amine Regenerator outlet temperature Overhead Cooler	32.73	°C
Analyzer H_2S in treated gas	5.33	ppm

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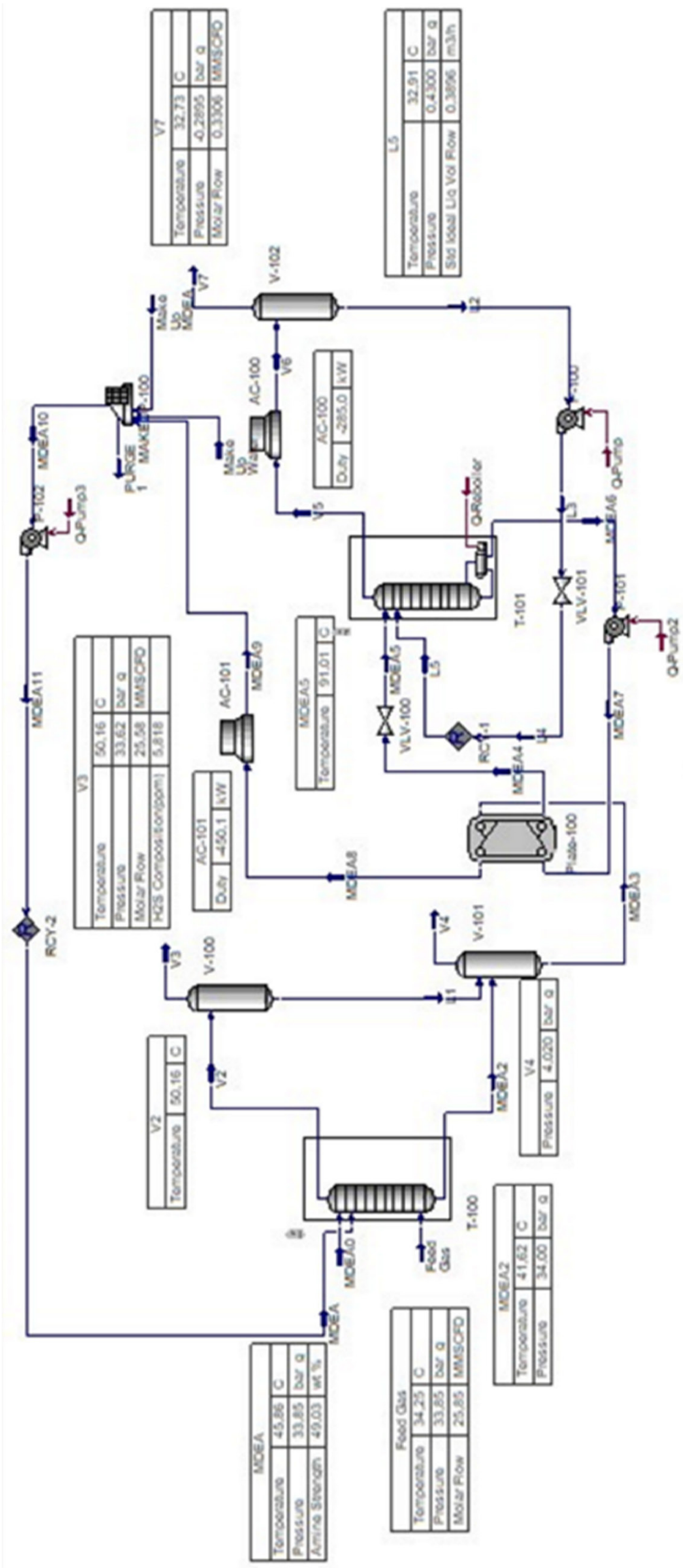

Figure 4
Simulation of H_2S removal unit by using aspen HYSYS

Table 2
Average natural gas composition data
(Primary Data 2024)

Composition	% mol or ppm
C_1	77.2335 % mol
C_2	7.0905 % mol
C_3	5.8145 % mol
iC_4	1.311 % mol
nC_4	1.4205 % mol
iC_5	0.354 % mol
nC_5	0.2135 % mol
C_{6+}	0.224 % mol
N_2	2.4005 % mol
CO_2	3.938 % mol
H_2S	410 ppm

Table 3
Amine composition mean data (Primary Data 2024)

Composition	% wt or ppm
MDEA	42.885 % wt
HC	11.9 ppm
H_2O	57.11381 % wt

Performance Evaluation of Lean Amine Cooler, Amine Regenerator Overhead Cooler and Plate Exchanger

Evaluation of the Amine Regenerator Overhead Cooler with Lean Amine Cooler, and Plate Exchanger is intended to determine the performance of the three tools and to answer the cause of the high temperature of lean amine inlet Amine Contactor (Mahfud & Sabara 2018). The following displays the evaluation findings for the Lean Amine Cooler, Amine Regenerator Overhead Cooler, and Plate Exchanger. According to Table 4, the simulated UA value is smaller than the design, which indicates that the performance of the Lean Amine Cooler is not good. In addition, the Lean Amine Cooler duty is only used 450.10 kW out of 645 kW, which means that the Lean Amine Cooler should be able to perform the Lean Amine cooling process. There is also the LMTD factor, which can indicate the performance of the Lean Amine Cooler; LMTD, which has a significant difference, indicates poor Lean Amine Cooler performance (Mc Cabe et al. 1993).

Table 5 shows that the simulated UA value is smaller than the design, indicating the performance of the Amine Regenerator Overhead Cooler is suboptimal. Furthermore, the employed obligation is only 285.02 kW out of 1,066.3 kW. This means that the Cooler can still cool to its maximum temperature. The LMTD value is also far from the design, which indicates that the performance of the Amine Regenerator Overhead Cooler is not good (McCabe et al. 1993). According to Table 6, it is evident that the Plate Exchanger performance is in good condition because the simulation UA value is greater than the design. So, it can be said that only a small amount of fouling in the Plate Exchanger inhibits heat transfer. Since only the Lean Amine Cooler and Amine Regenerator Overhead Cooler perform poorly, researchers recommend maintaining and cleaning the two Coolers. Fouling may hinder heat transfer in the Cooler (Smith et al. 2005). In addition, the fin fan can be checked to see whether it is damaged, which can reduce the cooling power of the cooler (Wuryanti 2016). There is also a weather factor. If the weather is hot, the cooling air used will cause the cooling process by the Cooler fin fan to be less than optimal, and vice versa.

H_2S Removal Unit Process Modification

After knowing the cause of the high lean amine inlet temperature of the Amine Contactor and having also been given recommendations related to the problematic equipment, the researcher tried to find other alternatives to reduce the lean amine inlet temperature of the Amine Contactor. The alternative was to create a reflux bypass from the The Rich/ Lean Amine Exchanger's regenerator for the rich amine stream and add heat transfer surface area in the Plate Exchanger (Alexander n.t.). This process modification uses the existing design base. Still, there is only the addition of bypass flow and heat transfer surface area in the Plate Exchanger, in this case, the addition of the number of plates. The number of plates determines the increase in the number of plates, which now only amounts to 83, while the Plate Exchanger capacity is 109. If the number of plates is filled to 109, it can increase the heat transfer surface area from 50.2 m^2 to 62.17 m^2. The display of the modified H_2S removal unit as seen in Figure 5.

Table 4
Lean amine cooler performance evaluation

Parameter	Simulation	Design	Description
UA (W/°C)	24,967.91	58,287.75	Smaller than design indicates poor Cooler performance
Duty (W)	450,097.03	645,000	Duty has not been used at all
LMTD (°C)	0.38	14	There is a huge difference

Table 5
Performance evaluation of amine regenerator overhead cooler

Parameter	Simulation	Design	Description
UA (W/°C)	22,333.75	44,635.55	Smaller than design indicates poor Cooler performance
Duty (W)	285,019.61	1,066.300	Duty has not been used all
LMTD (°C)	-3.96	29.1	There is a vast difference.

Table 6
Plate exchanger performance evaluation

Parameter	Simulation	Design	Description
UA (W/°C)	56,505.55	55,469.39	Larger than design, Plate Exchanger performance in good condition

It is evident from Figure 5 that there are additional components in the modified H_2S removal unit, namely, Splitter and Mixer. In the simulation, it can be seen that the output of the Reflux Pump will be divided into two streams with a specific flow ratio (shown in the red box). The flow partly flows partially to the Mixer inlet Rich/Lean Amine Exchanger and partially to the Amine Regenerator. The purpose of this H_2S removal unit modification is to reduce the outlet temperature of the Rich/Lean Amine Exchanger so that the outlet temperature of the lean amine cooler will drop. In this case, the assumption used in the simulation is the performance of the lean amine cooler, which is considered the same as the field situation. Later, the outlet temperature of the lean amine cooler can be known when the performance of the lean amine cooler is still the same as the field situation (Rahmatika et al. 2019).

From the simulation results, it can be seen that the simulation has converged, which means that the simulation was successful. Based on the review of the researchers, the results of the modification of the H_2S removal unit are influenced by the temperature of the lean amine inlet Amine Contactor. The effect is a decrease in the temperature of the lean amine inlet Amine Contactor. However, the reduction in temperature needs to be studied again using trials of specific variables to find the optimum conditions. The optimum condition of the H_2S removal unit will be determined in the following discussion.

H_2S Removal Unit Operating Parameter Optimization

Optimization of H_2S removal unit operating parameters is intended to lower the temperature of the lean amine inlet Amine Contactor in order to achieve ideal operating conditions in the H2S removal unit (Edgar et al. 2001). This optimization is carried out by trial and error on Aspen HYSYS simulation where a trial of reboiler duty from 1026-2052 kW, reflux ratio k regenerator and mixer 100%, 80%, 60%, 40%, 20%, and 0%, and plate exchanger surface area 50.2 m^2 and 62.17 m^2. From the results of trial and error, the most optimum condition will be sought, with the objective function being the low lean amine inlet temperature of the Amine Contactor. The constraints used in the optimization are the H_2S removal unit design operating conditions. The following shows the results of the optimization of H_2S removal unit operating parameters:

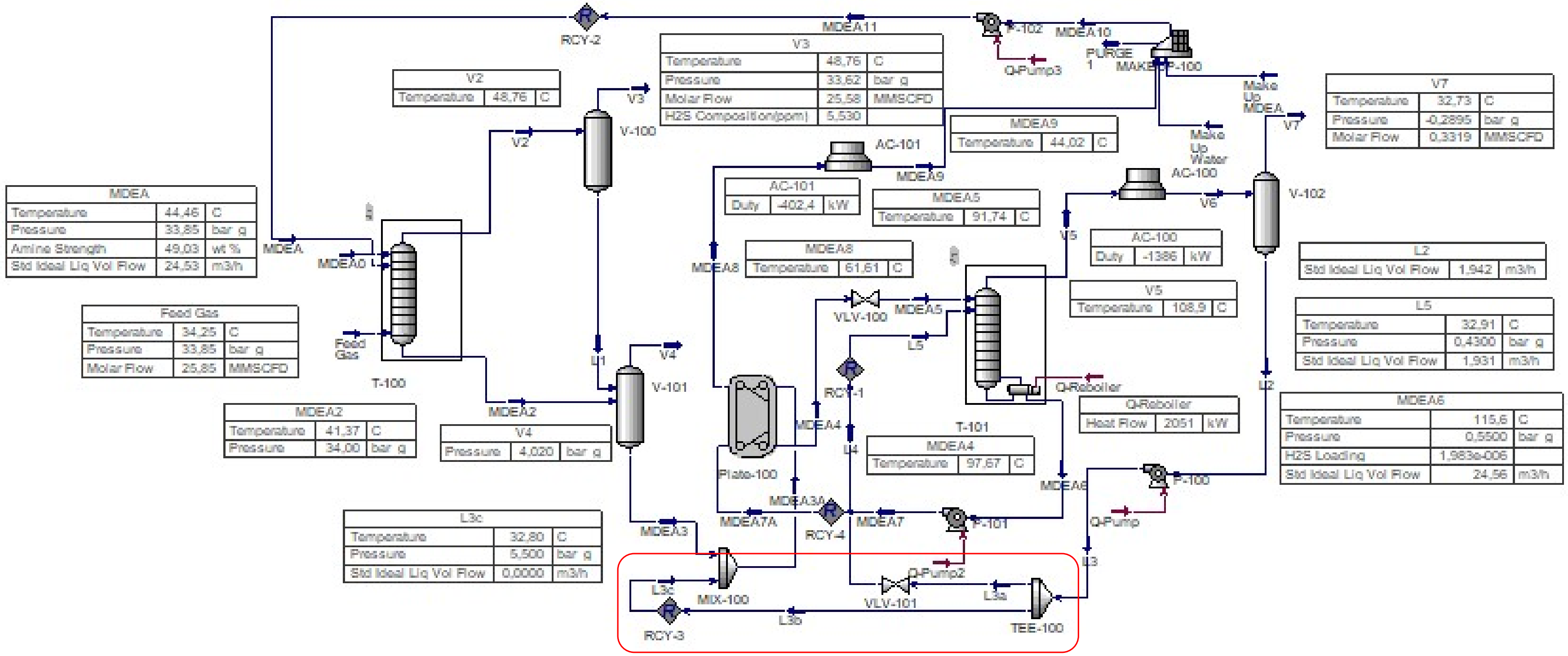

Figure 5
H_2S removal unit modification

Table 7
H_2S removal unit operating parameter optimization results

Parameter	Actual	Design	Optimization	Description
Reboiler Duty (kW)	1,026	Max. 3,893.4	1,642	Meet
Reflux Ratio (To Regenerator, %)	100	Max. 100	0	Design Optimization Results
Plate Exchanger Surface Area (m^2)	50.2	Max. 62.17	62.17	Meets
Regenerator Bottom Temperature (°C)	115.6	Max. 118.6	115.6	Meets
Regenerator Top Temperature (°C)	98.48	Min. 94.7	107.7	Meets
Flowrate Lean Amine Out Regenerator (m^3/h)	24.56	Max. 48.2	24.58	Meets
H_2S Loading Lean Amine Out Regenerator	0.00006955	-	0.00000577	Meets
Liquid Flowrate from Amine Reflux Drum (m^3/h)	0.3883	Max. 1.52	1.4	Meets
Liquid Temperature Inlet Regenerator (°C)	32.91	Max. 48.9	0	Design Optimization Results
Liquid Volume Inlet Regenerator (m^3/h)	0.3890	Max. 1.52	0	Design Optimization Result
Liquid Temperature Inlet Mixer (°C)	0	Max. 48.9	32.8	Design Optimization Result
Liquid Volume Inlet Mixer (m^3/h)	0	Max. 1.52	1.41	Design Optimization Result
Lean Amine Temperature Out Plate Exchanger (°C)	65.07	Max. 150	60.26	Meets
Rich Amine Temperature Out Plate Exchanger (°C)	94.72	Max. 150	95.54	Meets
Lean Amine Cooler Duty (kW)	450.20	Max. 645	384	Meets
Amine regenerator Overhead Cooler Duty (kW)	284.10	Max. 1,0066.3	1,002	Meets
Lean Amine Temperature Inlet Amine Contactor (°C)	45.92	Min. 41.63	43.8	Meets
Gas Temperature Out Amine Contactor (°C)	50.15	Min.44.1	48.12	Meets
H_2S Composition in Sweet Gas (ppm)	6.262	16	5.504	Meets

According to Table 7, it is evident that there is an influence between the addition of Plate Exchanger surface area on the lean amine temperature inlet amine contactor and amine contactor output gas temperature, duty amine regenerator overhead cooler, lean amine cooler, and lean amine temperature of the plate exchanger output. Adding a Plate Exchanger surface area of 62.17 m^2 will cause a decrease in Plate Exchanger output lean amine temperature, duty Lean Amine Cooler, Amine Contactor inlet lean amine temperature, and Amine Contactor output gas temperature. However, the addition of the Plate Exchanger surface area results in an increase in the duty of the Amine Regenerator Overhead Cooler, which is due to the rise in the rich amine temperature of the Plate Exchanger output (Christie & Geankoplis 1983).

From the previous explanation, it can be concluded that the increase in Reboiler duty, the increase in heat transfer surface area on the Plate Exchanger, and the more liquid flowing into the Mixer can reduce the Plate Exchanger output lean amine temperature, Lean Amine Cooler duty, Amine Contactor inlet lean amine temperature, and Amine Contactor output gas temperature. Thus, the independent variables that have been determined are appropriate for optimizing the operating parameters in the H_2S removal unit.

In addition, Table 7 shows the optimum operating conditions for reducing the lean amine inlet Amine Contactor temperature. The optimum condition is the Reboiler duty of 1,642 kW, the Amine Reflux Drum output liquid flowrate is 1.4 m^3/hr, and the reflux ratio is all fed into the Mixer. With these optimum conditions, the Amine Regenerator Overhead Cooler duty obtained is 1,002 kW, the lean amine temperature output from the Plate Exchanger is 60.26°C, the rich amine temperature output from the Plate Exchanger is 95.54°C, duty of the Lean Amine Cooler is 384 kW, the inlet temperature of the lean amine in the Amine Contactor is 43.8°C, the Amine Contactor outlet gas temperature is 48.12°C and the H_2S composition is 5,504 ppm.

Compared with the design data sheet, the optimization result for the Reboiler duty is 1,642 kW. In contrast, the design is 3.8934 MW, which means that not all of the Reboiler duty has been used so that the optimization results are valid. For the Amine Reflux Drum output liquid flowrate parameter, the optimization result is 1.4 m^3/hr, while the average capacity of the Amine Reflux Pump design is 1.52 m^3/hr. This means that the pump capacity can still pump liquid to the Mixer. In addition, the duty of the Amine Regenerator Overhead Cooler optimization result is 1,002 kW, while the design is 1,066.3 kW. This means that the Cooler is still able to operate under optimized conditions. For the last parameter, namely the Lean Amine Cooler duty, the optimization condition is obtained at 384 kW while the design is 645 kW. This means the Cooler workload is still far from the maximum design limit and can still carry out the cooling process.

For the parameters of lean amine temperature output from the Plate Exchanger, lean amine inlet Amine Contactor temperature, and Amine Contactor outlet gas temperature when compared to actual data, there is a decrease from actual conditions, which means that the optimization was successful. The output lean amine temperature from the Plate Exchanger optimization results is 60.26°C while the actual is 65.07°C. There is a decrease of 4.81°C in the output lean amine temperature from the Plate Exchanger. For the lean amine inlet temperature of the Amine Contactor, the optimization result is 43.8°C while the actual is 45.86°C, which means a temperature decrease of 2.06°C. In addition, for the Amine Contactor outlet gas temperature, the optimization results were obtained at 48.12°C while the actual was 50.16°C, which means there was a decrease in temperature of 2.04°C. From the discussion above, it can be concluded that the optimization of the process design and operating parameters of the H_2S removal unit was successfully carried out to reduce the temperature of the lean amine inlet Amine Contactor.

CONCLUSION

It is evident from the simulation results and the aforementioned analysis that the cause of the high lean amine inlet temperature of the Amine Contactor is a decrease in the performance of the Amine Regenerator Overhead Cooler and Lean Amine Cooler. The evaluation results of the Lean Amine Cooler with Amine Regenerator Overhead Cooler show poor performance because the simulated UA and LMTD values are smaller than the design UA and LMTD. At the same time, the performance of the Plate Exchanger is still in good condition because the simulated UA is greater than the designed UA. Optimization of process design and operating parameters of the H_2S removal unit was successfully carried out to reduce the lean amine inlet temperature of the Amine Contactor. The appropriate H_2S removal unit process design configuration is to create a reflux bypass from the enhance the plate exchanger's surface area for heat transfer and regenerate the rich amine stream entering the rich/lean amine exchanger to 62.17 m^2. The influential operating parameters are the duty of the Reboiler, the liquid flow rate flowing into the Mixer, and the addition of heat transfer surface area on the Plate Exchanger. The optimum H_2S removal operating condition is the Reboiler duty of 1,642 kW, the Amine Reflux Drum output liquid flowrate is 1.4 m^3/hr, the reflux ratio is all put into the Mixer, and the Plate Exchanger heat transfer surface area is 62.17 m^2.

The researcher also provided suggestions to the company in the form of installing a temperature indicator to measure the outlet air temperature of the Cooler, performing maintenance and cleaning of the Lean Amine Cooler and Amine Regenerator Cooler, making The Rich/Lean Amine Exchanger receives a rich amine stream via a reflux bypass from the Regenerator. to get a lower lean amine inlet Amine Contactor temperature and increasing the number of plates to 109 plates on the Plate Exchanger so that the heat transfer surface area becomes 62.17 m^2.

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GLOSSARY OF TERMS

Symbol	Desinition	Unit
MDEA	Methyl Diethanol Amine	
HC	Hydrocarbon	
UA	Heat Transfer Coefficient	
LMTD	Log Mean Temperature Difference	

REFERENCES

Abdel-Aal, H.K., 200, Petroleum Engineering. National Research Center Egypt.

Adikharisma, R., 2014, Performance Analysis of CO_2 Removal Process in Absorber Column at Ammonia Plant Unit 1 PT Petrokimia Gresik. Sepuluh Nopember Institute of Technology.

Alexander, M.A., n.t.. Mass Balance and Energy Balance of Integrated Waste Management - Penujah Tegal Regency. TEKNOBIZ Scientific Journal, 8(3), 129-138.

Aziz, P.A., Rachmat, M., Chandra, S., Daton, W., N. & Tony, B., 2023, Techno-Economic Solution for Extending CCUS Application in Natural Gas Fields: A Case Study of B Gas Field in Indonesia. Scientific Contributions Oil and Gas, 46(1), 19-28. https://doi.org/10.29017/SCOG.46.1.1321.

Christie, J. & Geankoplis,1983, Transport Process and Unit Operation. PTR Prentice- Hall Inc, Englewood Cliffs, New Jersey.

Edgar, T.F., Himmelblau, D.M. & Lasdon, L.S., 2001, Optimization of Chemical Processes (2nd ed.). McGraw-Hill.

Fatimura, M. & Fitriyanti, R., 2018. Handling Sour Gas Contained in Natural Gas into Sweetening Gas. 3(2), 55-67.

Fuqoha, I., 2012, Design and Cost Estimation of Acid Gas Separation Unit with High CO_2 and H_2S Content. University of Indonesia.

Giffari, F., Widiastuti, P., Rosmayati, L., Nofrizal & Kusdiana, D., 2021, A New Approach for East Natuna Gas Utilization. Scientific Contributions Oil and Gas, 44(3), 215-221. https://doi.org/10.29017/SCOG.44.3.713.

Jones, D.S.J., 2016, Handbook of Petroleum Processing. Springer.

Kurniawan, Dinar, Hananto, 2024, Redesign of Electric Submersible Pump (ESP) in Gas Containing Well "W- 30" Field "A". Oil and Gas Publication Sheets, 58(1), 1-11. https://doi.org/10.29017/LPMGB.58.1.1610.

Mahfud, M. & Sabara, Z., 2018, Indonesian Chemical Industry (1st ed.). Deepublish.

McCabe, Warren L, Julian C. Smith & Peter, H., 1987, Chemical Engineering Operations. Fourth edition Erlangga. Jakarta.

Michael, S. 2021. Analysis of Gas Sweetening to Remove H_2S and CO_2 Gases from Marketable Gas Production Using Numerical Methods.

Ministry of Education and Culture of the Republic of Indonesia, 2015, Gas Processing. Ministry of Education and Culture of the Republic of Indonesia.

Mujiyanti, S.F., 2018, Plantwide Control Design at Gas Processing Facility (GPF) Plant. Sepuluh November Institute of Technology.

Rahman, R.A., 2022, Simulation of Acid Gas Removal from Natural Gas Stream using Aspen Hysys. Journal of Technoscientia Technology, 14(2), 235-242.

Rahmatika, F.A., Ariq, Y.N., Susianto, & Taufany, F., 2019, Pre-Design of LPG Plant from Natural Gas. Its Engineering Journal, 8(2), 46-51.

Sari, P., 2017, Aspen Hysys simulation of absorption column. E-Journal of AKPRIND University Indonesia.

Smith, J.M. & H.C., V.N., 2005, Introduction to Chemical Engineering Thermodynamics Seventh Edition (7th ed.). McGraw-Hill Book Company.

Sopurta, A., Siregar, P. & Ekawati, E., 2014, Design of HYSYS Simulation System & Integration with Programmable Logic Controller-Human Machine Interface: Case Study on Ethanol-Water Distillation Column Plant. J.Oto.Ktrl.Inst, 6(1), 1-9.

Sugihardjo, 2022, CCUS-Greenhouse Gas Mitigation Actions and Enhanced CO_2-EOR Oil Depletion. Oil and Gas Publication Sheets, 56(1), 21-35. https://doi.org/10.29017/LPMGB.56.1.916.

Wuryanti, S., 2016, Mass and Energy Balance. Bandung State Polytechnic.

Yaws, C. L. 1999. Chemical Properties Handbook. McGraw-Hill Companies.