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Minimalization of Dissolved Heavy Hydrocarbon on Lean Solvent with Absorption Optimization

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Abstract

Pertamina EP DonggiMatindok Field has an Acid Gas Removal Unit (AGRU)which is an acid gas (H_2S) separator unit that flows from the LP Separator. An increase of pressure differential occurred in the AGRU indicates a foaming tendency and impacting on decrease in sales gas. The well switch method was carried out to overcome foaming event by opening the manual valve in stages from 25%, 50%, 75% and 100% with waiting time of 30 minutes each stage. Besides, solvent flow adjustment is carried out using HYSYS simulation to find optimal solvent flow requirements through ratio of flow balance between feed gas and lean solvent. This method aims to minimize heavy hydrocarbons dissolved in the solvent by optimizing absorption process. After implementing this method, a decrease occurred in the average solvent flow of 2,308 BPD at 10 MMSCFD feed gas, the pressure differential relatively stable at 3-4 psig which indicate no foaming event. Laboratory result shows that Heavy Hydrocarbon Content parameter were 60 mg/L and Particulate Matter Content (>0.45µm) was 22 mg/L. This method also extends the lifecycle of the solvent and has an impact on reducing the solvent packaging waste which categorized as toxic and hazardous waste.

Keywords: aspen hysys, lean solvent, absorption optimization

1. Introduction

Pertamina EP Donggi Matindok Field is a gas field equipped with two Central Processing Plant (CPP), namely Donggi CPP and Matindok CPP to produce gas and condensate. Based on the Gas Sales and Purchase Agreement, the daily nomination for Donggi Matindok Field (Daily Contract Quantity) is 93.92 MMBTUD or equivalent to 87 MMSCFD in 2022. If the daily nominations are not fulfilled, Donggi Matindok Field will be subject to a penalty from the buyer. In fulfilling

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the daily nomination of Donggi Matindok Field, there are several problems that cause the daily nomination to not be achieved. One of these causes is foaming event. Foaming is defined as the gas phase dissolved into a liquid phase resulting in a foam reaction. This reaction disrupts the process of absorbing CO_2& H_2S gas impurities causing the gas to be off-spec (not as per agreement spec).

Foaming occurs due to the presence of heavy hydrocarbon fractions dissolved in the amine circulation. Reducing the absorber pressure will increase the acid content due to an increase in component volatility (Park et al., 2021). Pressure reduction contributes to partial pressure of CO_2 decrease in the feed gas and consequently lowers reaction rate with amines, which decreases CO_2 removal efficiency (Febrianto et al., 2021).

In the production process, Donggi Matindok Field has an Acid Gas Removal Unit (AGRU) which is one of the H_2S acid gas separator units that flows from the LP Separator. As a result of the accumulation of hydrocarbons in the Separator, the output from the Separator unit carries excess liquid which still contains excess hydrocarbons to the AGRU, causing foaming to occur which results in off-spec CO_2 of 95 ppm. In August 2021, to achieve Gas Sales agreement, Matindok CPP increased its production to full capacity of 65 MMSCFD. Since November 2021, there has been an increase in the pressure differential in the Acid Gas Removal Unit (AGRU) which indicates a foaming tendency, thus causing a reduction in Sales Gas distribution. Then, in March 2022, the foaming frequency became very intense.

Pertamina EP Donggi Matindok Field realizes that production process activities need to pay attention to environmental aspects, including efforts to reduce the use of hazardous waste. Hazardous waste can cause danger to the environment and also impact public health and other living creatures if disposed directly into environment. Many of the environmental problems appeared nowadays are the impact accumulation of industrial waste management in ways that are bare minimum. Whether it's developed or developing countries, hazardous waste management is a fundamental global problem. In addition, there are economic benefits to sorting waste based on the hazardousness its pose and the compatibility and/or non-compatibility of its content with other chemicals in the waste stream for the invention of effective waste management strategy (Sadala et al., 2019). Donggi Matindok Field implements the reduction of hazardous waste through a program to minimize dissolved heavy hydrocarbons in lean solvents with absorption optimization. The solvent used is Methyl diethanolamine (N-methyl diethanolamine) or MDEA.

MDEA can be used as an unselective solution to detach impurities of gas in form of H_2S and CO_2 or can be used as a selective solvent which will remove H_2S rather than CO_2. Febrianto et al. (2021) stated that MDEA selectivity is influenced by:

1) Temperature: lower temperatures will increase selectivity
2) Pressure: lower pressure will increase selectivity
3) CO_2/H_2S ratio: higher ratio will support selectivity

To minimize the use of solvents in reducing hazardous packaging waste, Donggi Matindok Field monitors parameters to prevent foaming. Some similar cases that occurred are as follows:

Table 1. State of the Art

Authors	Year	Objective of Study
B. Zarenezhad and A. Aminian	2011	Creating an artificial neural network model for design of wellhead chokes under wide range of flow conditions.
H. R. Nasriani and A. Kalantariasl	2014	Developing individual empirical correlations to be applied to predict gas flow rates in high-rate gas condensate wells under subcritical flow condition.
Jaswara Koto	2014	Analysing absorption acid gas removal in liquefied natural gas process. Simulating fluid mechanic of amine absorber process in removing carbon dioxide and hydrogen sulfide from in LNG production plant.
Eve Masurel, Olivier Authier, Christophe Castel & Christine Roizard	2015	Developing solvent selection in removing impurities based on bubbling point and absorption cell measurements.
Bahman ZareNezhad & Ramezan Khorramirad	2016	Predicting maximum hydrogen sulfide absorption capacity using neuro-fuzzy model in sour gas prewash units.
Alireza Afsharpor	2017	Modeling of H_2S solubility aqueous MDEA solution using electrolyte SRK plus association equation of state.
Zheng Tong, Guangmin Zhao, Songbo Wei	2018	Analysing a novel intermittent gas lifting and monitoring system toward liquid unloading for deviated wells in mature gas field.
V.B. Volovetskyi, A.V. Uhrynovskyi, Ya.V. Doroshenko, O.M. Shchyrba, Yu.S. Stakhmych	2020	Developing a set of measures to provide maximum hydraulic efficiency of gas gathering pipelines.
Humbul Suleman, Kaj Thomsen, Philip Loldrup Fosbøl, Abdulhalim Shah Maulud & Rizwan Nasir	2021	Modeling and estimating hydrogen sulfide solubility in aqueous alkanolamines in the high pressure-high gas loading region.

2. Methods

Before minimizing dissolved heavy hydrocarbons in lean solvent by optimizing absorption, an initial problem analysis is carried out using several methods as follows:

2.1 Fishbone Analysis

Fishbone analysis was developed and disseminated by Kaoru Ishikawa in 1974. Fishbone

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diagrams are sometimes referred to as cause-and-effect diagrams. Luo et al. Al. (2017) consider Fishbone diagrams to create organized complex systems and qualitatively analyse the causes of risk. Meyer et al. (2013) describes the Ishikawa Diagram as a possible cause-and-effect tool that is used functionally in brainstorming sessions to investigate factors that might influence a particular situation, condition or circumstance produced by a course system and has been widely used among large company in worldwide in the first decade after its initiation.

This technique emerged because of the need to: (a) clearly identify the problems or challenges an organization is facing; (b) gather the ideas of a small group of interested parties(c) identify the cause-and-effect components of the problem or challenge; and (d) provide a visual representation of steps (a) through (c) in such a way that the actual cause or causes of the problem are identified, properly classified, labelled, and understood by the persons concerned. This approach facilitates prioritization, so that it can produce the right solution. Risk analysis using the Fishbone issue can be seen in the image below.

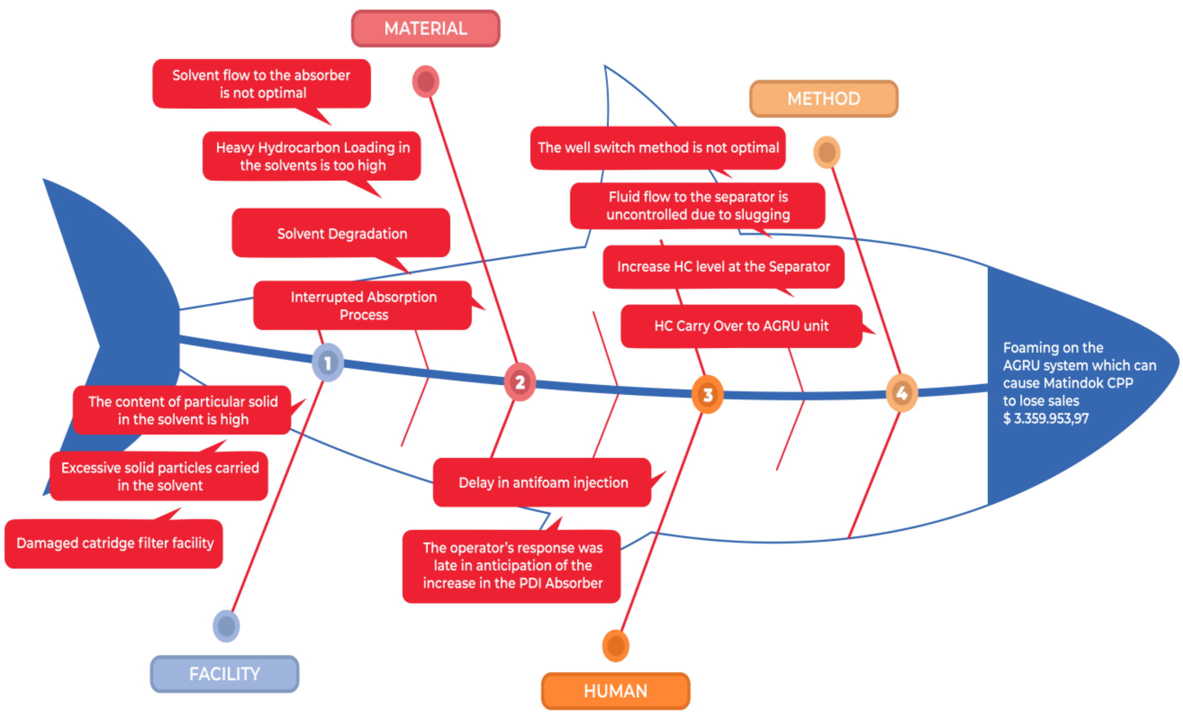

Figure 1. Fishbone Analysis

From the fishbone analysis, correlation analysis is obtained as follows.

Table 2. Correlation Analysis

No	Causal Factors	Analysis	Field Test Results	Correlation
A	Method	The previous well switch method is not optimal, resulting an increase of HC level in the Separator Unit which would cause HC carry over to the AGRU and cause foaming	The Separator level trend has reached 100% and laboratory analysis results in the solvent containing heavy hydrocarbons	Yes
B	Material	The solvent flow is not optimal, causing the heavy hydrocarbon loading in the solvent to be high. This leads to solvent degradation and causing the absorption process to be disrupted hence foaming occurred	Solvent lab test result proofed there is heavy hydrocarbon content in the solvent	Yes
C	Facility	The cartridge filter facility is damaged causing solid particles to be carried in the solvent hence causing the solid particulate content in the solvent high and foaming	Visual check results of the Mechanical Filter and After Filter and Solvent Lab Test results prooved there were particulates	Yes
D	Human	The operator's response to antifoam injection greatly influences foaming handling	There is a PDHH (Pressure Difference High Alarm) alarm on the absorber unit so that the operator's response is optimal. Apart from that, antifoam injection does not prevent foaming from occurring but only reduces the tendency for foaming to occur	No

2.2 Failure Modes Effect Analysis

Failure Mode Effect Analysis (FMEA) is one of the best-known quality management tools used to examine and eliminate failures, issues, and mistakes in systems, designs, procedures, and services that could be addressed to raise quality and dependability (Liu et al., 2017). The FMEA method provides decision maker useful information for making decisions by identifying the

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potential failure points and mechanisms of a specific product or process. Rooted in total quality management (TQM), FMEA can preemptively recognize and evaluate critical failures during the early stages of system or product development (Liu et al., 2017). FMEA, in contrast to other risk analysis methodologies, focuses on identifying possible failure modes, examining the causes of each failure mode and how it affects the system, and finally minimizing or preventing significant failures before they happen. Moreover, FMEA can reduce costs, improve quality, shorten product development cycles and increase customer satisfaction, etc. Because of its advantages, FMEA is currently widely utilized in several industries, including the automotive, electronics, maritime, and health sectors, for reliability analysis.

2.3 Aspen HYSYS

The modeling of production units using specialized software is one of the most significant computer applications in the oil, gas, and petrochemical industries. Commercial software called Aspen HYSYS is used to create process stability and optimize operating parameters. The entire archive of information and thermodynamic equations is available at Aspen HYSYS. It makes this software stand out as one of the most practical and efficient tools for optimization and simulation.

Computer simulation is one of the important steps in process optimization (Shankar et al., 2016). Process modeling analysis and integrated design tools can be accessed through the Aspen HYSYS and Aspen Plus process simulators. Optimization of crude oil separation processes is becoming increasingly important due to high energy costs and ecological demands on product quality. The majority of the dual Hydrocarbon-non-Hydrocarbon systems and paired and upgraded mutual dual coefficients from the Hydrocarbon-Hydrocarbon library (a measurable component derived from interaction parameters) are contained in the Peng–Robinson and Soave–Redlich–Kwong equations of state. The interaction parameters for materials that are not in Aspen HYSYS's library are automatically generated by HYSYS in order to improve the stimulation of vapor–liquid equilibrium (Jalali et al., 2019).

2.4 Alternative Solutions

2.4.1. Upgrading Separator and Upgrading Propane Chiller

In the oil and gas industry, the presence of foam can be useful for gas injection and especially CO_2 flooding can be used to increase oil recovery (Rafati et al., 2012). However, foaming in crude oil can cause difficult problems in several other stages of oil and gas production. A negative effect of crude oil foaming is that it causes the separator capacity to decrease since the foam breakdown time increases. Another consequence is inaccurate level measurement. Foam has the potential to allow liquid to pass through the gas line, contaminating the solvent and harming the scrubber and compressor. To such extent, foaming may result in the release of dangerous gases and damage to the pump. Foam inhibition provides better process control over the separation and distillation of oil and gas and therefore laboratory tests of the foaming and antifoam performance of oil and gas are necessary (Chen et al., 2018).

2.4.2. Installing Slug Catcher in Gas Well

The most popular passive slug removal technique is slug catchers. They serve as buffer tanks and occasionally even divide the liquid and gas beforehand. By acting as actual low-pass filters, the slug catchers will filter out the high-frequency oscillating influx and produce a smooth outflow. An early stages separation method was carried out and implemented in McGuiness and Cooke (1993) to prevent multiphase flow completely from the transportation pipeline. The concept was to use a separator at the top of the well to separate the gas, water, and oil. The cost of several single-phase pipelines is significantly higher than that of a single multi-phase pipeline, making this approach both efficient and costly.

The increase in slug volume that occurs also appears to be directly proportional to the increase in pipe diameter, while the pressure gradient that occurs is inversely proportional to the increase in pipe diameter. This is in accordance with the results of experiments on slug flow in horizontal pipes that were carried out (Jepson dan Taylor, 1993). The "Casing-heading" mechanism in the gas-lifting production well explains similar slug behavior. Here, the gas lifting creates a build-up of pressure inside the casing without any production until the gas injection rate from the casing to the tubing varies, causing a blow-out phase to occur (Pedersen et al., 2016). An illustration of the gas-lifting production well is presented in Figure 2.

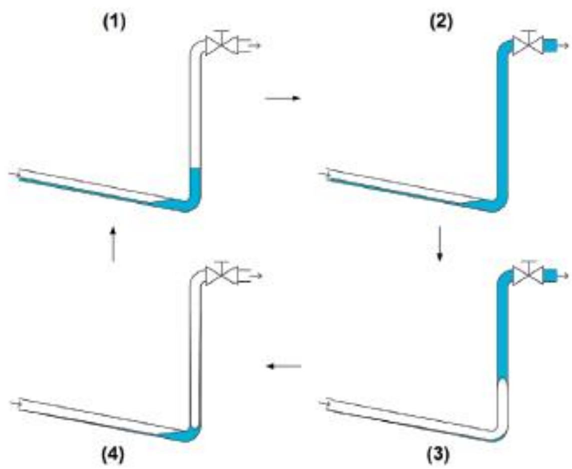

Figure2. Illustration by Biltoft et al. (2013) about cycle behavior on riser pipe when there is slug. The cycle consists of 4 steps: slug formation, slug production, liquid blowout, and gas surge.

There are two choke valves used for control: one downstream of the tubing for production control and one for gas injection into the annulus. Besides, a check valve is located on the connection between the annulus and the tubing. The work examined inXu dan Golan (1989) described the gas-lift casing-heading repeating cycle, similar to what can be observed on each cycle in Figure 2: (1) More gas is injected into the tubing through the downhole orifice when there is a fast drop in the flowing tubing pressure at the annulus connection to the well tube, which indicates the static pressure in the tubing's bottom hole. (2) Increased gas discharge will result in more gas to pass through the down hole orifice by further lowering the running tube pressure. (3) The casing pressure and the upstream pressure at the down hole orifice will decrease because the gas supply through the surface choke is unable to supply the increased gas rate injection into the production tube. (4) The pressure inside the flowing tubing begins to rise. As a result, the tubing's gas flow decreases and the drop in gas injection into the tubing continues. (5) The high flowing tubing pressure and low annulus pressure cause the down hole orifice to inject less gas than the gas injection can supply. As a result, the casing pressure increases. (6) The gas injection rate into the production tube rises along with the casing pressure, which lowers the tubing flowing pressure. For every slug cycle, these actions are repeated. The detrimental effects of extreme slugging flow on the production facilities have been well researched in (Pedersen et al., 2016). The studies conclude that the main negative impacts of the slug are as listed below:

a. High pressure in the separators and liquid overflow
b. Gas compressor overload
c. Increased corrosion
d. Low production
e. Production slop

2.4.3. Optimization of Well Switch Pattern Operation and Solvent Flow Adjustment with Well Test Solvent (WTS) Method

Apart from heavy dissolved hydrocarbons in lean solvent, analysis of the factors leading to foaming was also found, it was because an error in the well switch method. Initially, the switch method directly sets the manual aperture at 100% without paying attention to the gradual waiting time. Meanwhile, the feed gas still carries condensate with heavy hydrocarbons and is in contact with solvents. This causes the solvent to become damaged due to contamination with hydrocarbons so that it needs to be made up continuously. This heavy hydrocarbon content then condenses and changes phase from gas to liquid which causes foaming. Furthermore, it has been demonstrated that subpar process control can result in unintended environmental harm, such as excessive waste or unintended effects like energy consumption and overcapacity. As a result, in chemical applications, optimizing production capacity, reducing energy consumption, and/or eliminating waste have become essential elements of controller design (Elmaz et al., 2023).

With the development of switching system theory, the problems of regulating and protecting gas turbine engines have been widely studied in the last decades. Csank (2010) provides a design method for a generic commercial aircraft engine gain scheduled PI switching control system. Richter (2011) controlled a turbine fan engine with sliding mode control and proved the stability of the system based on min/max switching theory. May (2012) proposed a modification of the min/max switching structure. With conditional active limit regulators, improved response, while safety is also maintained. Based on an activated EME model, Shi (2016) introduced an event-triggered switching control technique for aero engines. In the min/max sliding mode control system, Yu (2018) added a core axis acceleration/deceleration limiter and gave asymptotic stability conditions for the entire controller. To conclude, the gas turbine switching control

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method is improved from both the switching logic and the regulating/protective loop structure (Ma, et al. 2021).

2.4.4. Chosen Alternative

Efforts made to overcome solvent damage due to contamination with gas containing heavy hydrocarbons were carried out in parallel between improving the well switch method and conditioning the solvent flow. Improvements to the well switch method are carried out by manually opening the valve gradually from 25%, 50%, 75% and 100% with a waiting time of around 30 minutes at each stage. Meanwhile, solvent flow adjustment was obtained by carrying out HYSYS simulations to calculate the correct solvent flow requirements with a ratio of feed gas through calculating the flow balance between feed gas and lean solvent to minimize and eliminate dissolved heavy hydrocarbons in the solvent. Reducing the solvent flow according to the HYSYS simulation results causes the absorption of hydrocarbons in the solvent to also be low. This is necessary to prevent excessive hydrocarbon contamination of the solvent so that the solvent can still be used properly with a lower make-up frequency. The frequency decrease of make-up solvents results in a decrease of solvent packaging waste generation which categorized as hazardous waste.

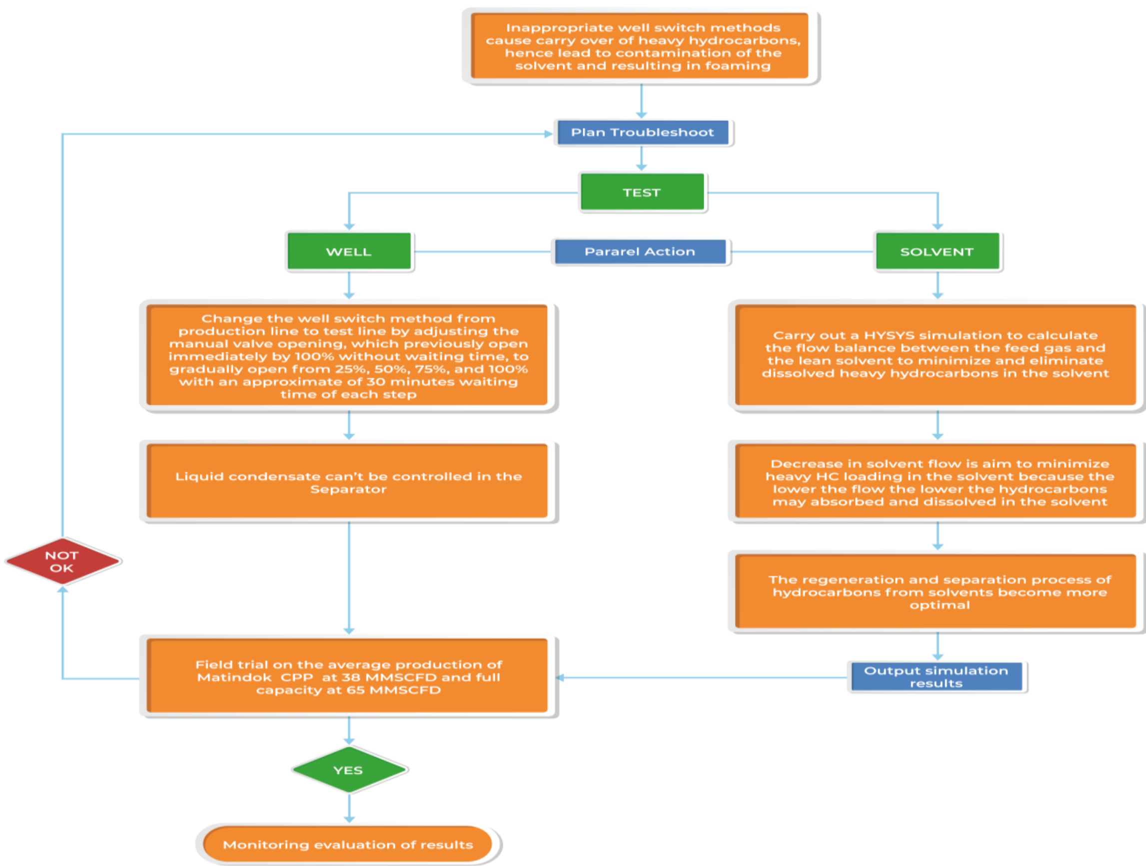

Figure 3. Well Switch Method

3. Results and Discussion

3.1. System Changes

In November 2021, there was an increase in the pressure differential in the AGRU which indicated a foaming tendency, causing a reduction in Gas Sales. Foaming on the AGRU system could causeMatindok CPP to lose sales of $3,359,953.97. From the results of the correlation analysis based on the Pareto diagram below, it is concluded that the well switch method is not optimal & the current solvent flow are the dominant causal factor because of the largest Total RPN with a total percentage of 99%.

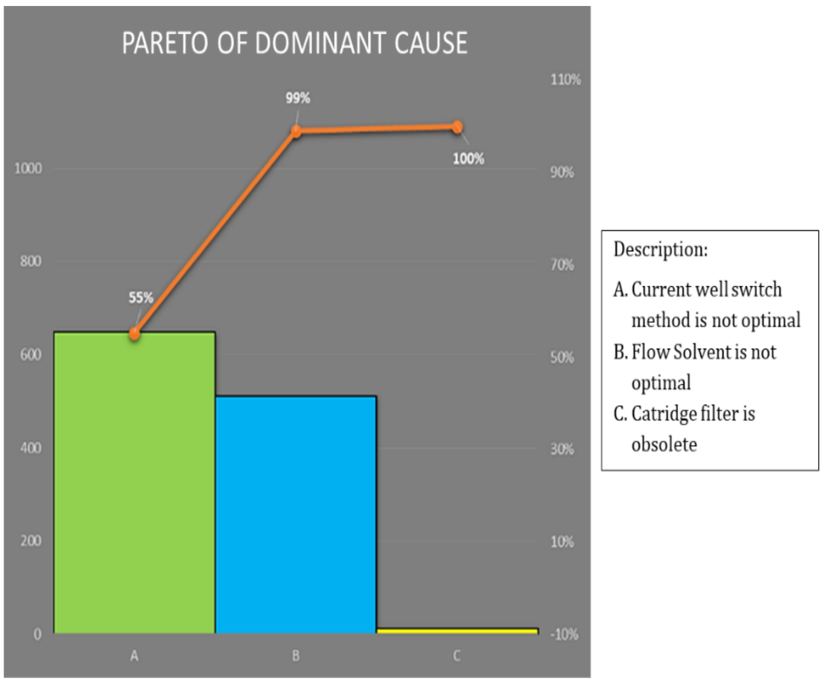

Figure 4. Pareto Diagram

Based on the dominant causal factor, Well Test Solvent (WTS) method is implemented by carrying out a trial & error method of switching the well from the production line to the test line by manually adjusting the valve opening which aim to control the Separator level. As for solvents, a lean solvent flow calculation simulation was carried out to obtain the optimum solvent flow in minimizing and eliminating the dissolved heavy hydrocarbon fraction in the solvent using HYSYS.

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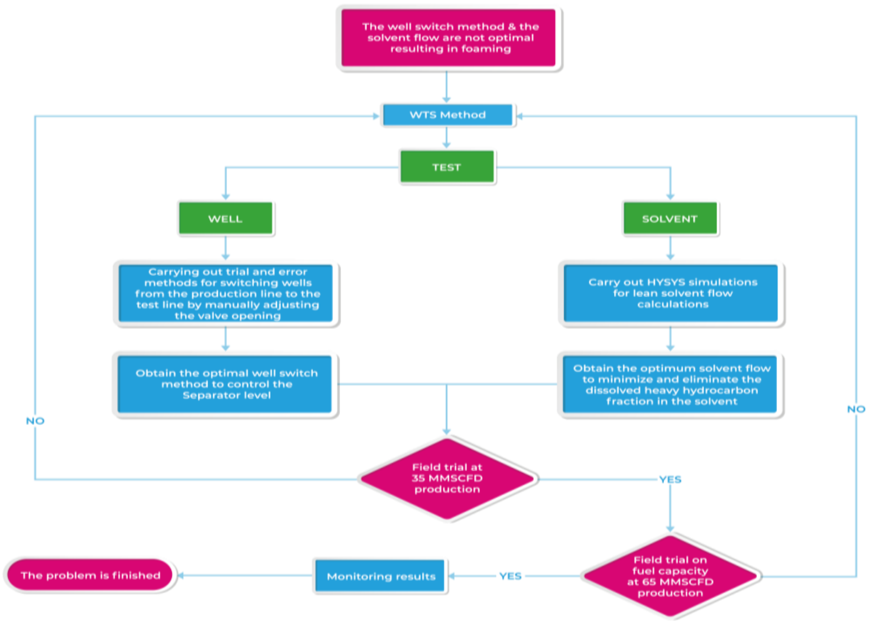

Figure 5. WTS Method Implementation

Through the application of the Well Test Solvent method, a selected alternative solution was obtained with minimal cost, short implementation time (4 months), and has moderate risk through optimizing the well switch and solvent flow operating patterns. This selected solution is carried out on the well valve before entering the Separator and adjusting the lean solvent in the AGRU unit.

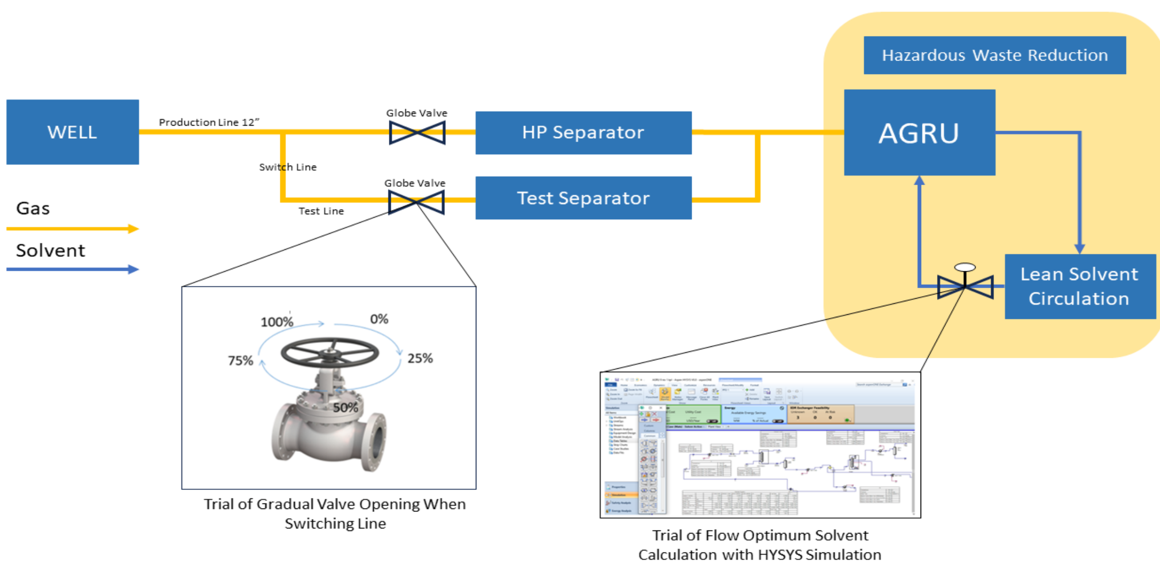

Figure6. Chosen Solution

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3.2. Evaluation of Valve Switch Line Operation

From the application of the WTS method that has been carried out, an optimal well switch method was obtained by opening the valve in stages where previously the valve opening process went directly from 0% to 100%. After process improvements, valve opening was carried out in stages from 0% - 25% - 50% - 75% - 100% and each stage has a waiting time of 30 minutes. This is done in order to control the liquid level in the Separator.

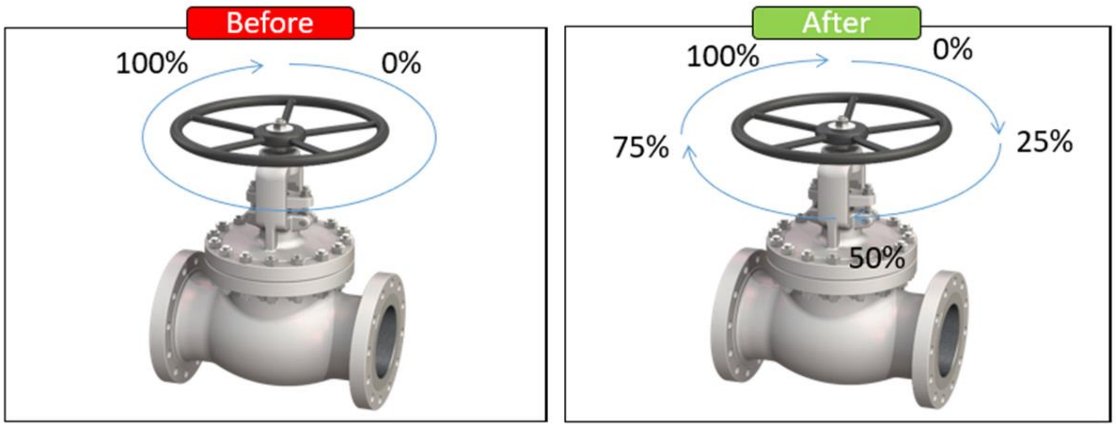

Figure7. Left: Before WTS Method Implementation; Right: After WTS Method Implementation

3.3. Evaluation of Separator Level Result

The image below shows the Separator level in the condition before improvement were carried out. There is a hydrocarbon level that reaches 100% as seen in Figure 8, which indicates the presence of hydrocarbon carry over leading to foaming in the AGRU system.

Figure8. Separator Level Before Improvement

After improvement was carried out with WTS method, hydrocarbon level at Separator is relatively stable on 17% as seen in Figure 9, and there is no foaming event happened.

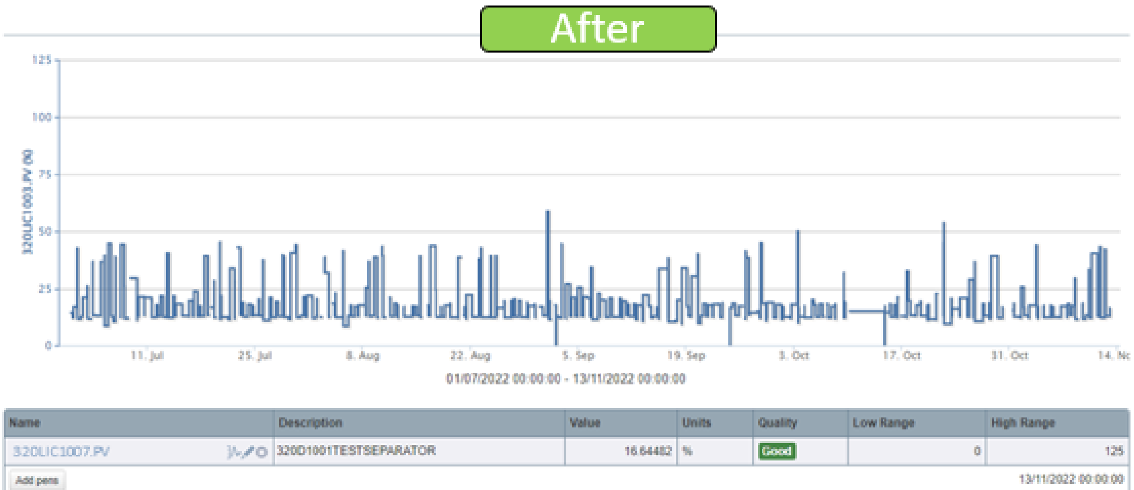

Figure 9. Separator Level After Improvement

3.4. HYSYS Simulation Result

HYSYS simulation is carried out by creating a process flow diagram in HYSYS. Then, carry out simulations and create a Heat Material Balance table, as well as carry out a trial calculation of flow lean amine. The HYSYS simulation is done first for production of 35 MMSCFD and second at maximum production conditions of 65 MMSCFD. The trial & error results of the HYSYS simulation in calculating the balance between flow feed gas and lean amine resulted in smaller solvent flow than the previous design basis. This minimizes the heavy hydrocarbon loading fraction in the solvent which makes the regeneration and separation process of hydrocarbons from the solvent more optimal. This also succeeded in minimizing the occurrence of foaming at Matindok CPP. The result of the lean amine flow calculation in Figure 10 shows a temperature of 99˚F and a pressure of 180 psig at a molar flow of 42.27 MMSCFD. While the ideal liquid volume flow is 15,000 BPD.

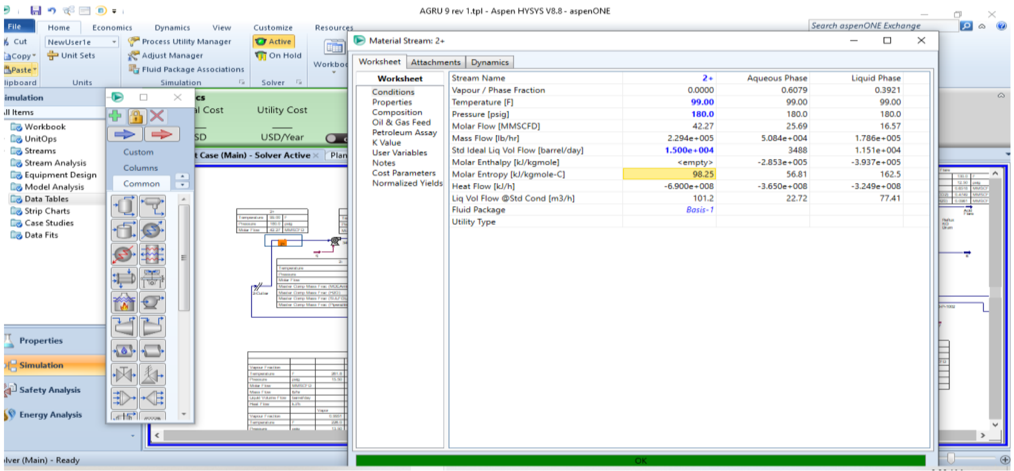

Figure 10. Flow Lean Amine Result on HYSYS

Figure 11 shows a simulation with a feed gas of 35 MMSCFD with temperature of 92˚F and a pressure of 895 psig with a dominant methane of 89.89% mol and details of the gas compositions also listed. The feed gas will go to the KO Drum at temperature of 69˚F and a pressure of 890 psig then to the Acid Gas Absorber at a flow of 30 MMSCFD with temperature of 108˚F and pressure of 881.4 psig. In the Acid Gas Absorber, the gas will be contacted with 43% MDEA solvent at flow of 10,000 BPD with temperature of 105˚F and pressure of 900 psig. At this time, the rich solvent formed will go to the Acid Gas Flash Drum then to the Amine Stripper Column and Amine Sump Drum. Meanwhile, the sweet gas produced will go to the KO Drum and flow to the next process, Dehydration Unit (DHU), at a rate of 30 MMSCFD with temperature of 108˚F and pressure of 880 psig.

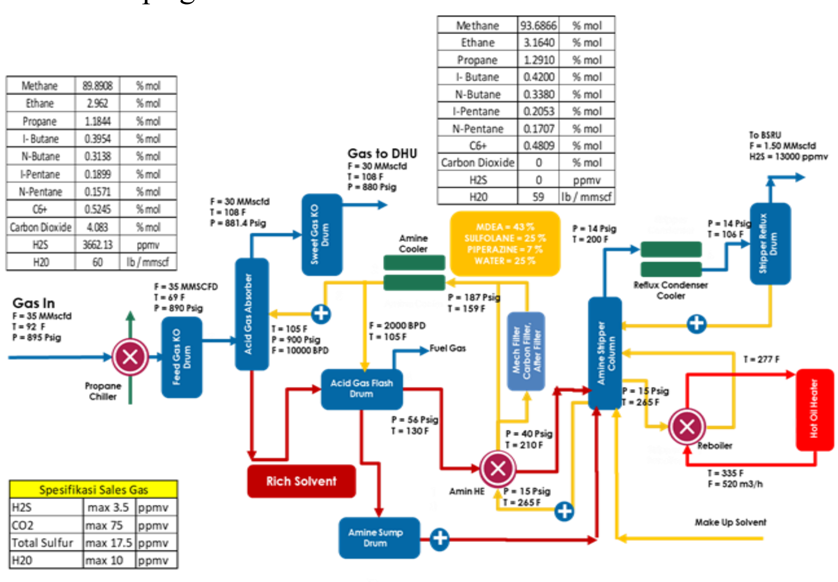

Figure11. HYSYS Simulation Result in AGRU

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Figure 12 shows a comparison of the use of flow solvent before and after the well test solvent method on certain feed gases. Before implementing the WTS method, feed gas at full capacity of 65 MMSCFD required a solvent flow of 18,000 BPD. After implemented well test solvent method, the 65 MMSCFD gas feed only requires a solvent flow of 15,000 BPD.

BEFORE

Feed Gas	Flow Solvent
MMSCFD	BPD
10	2.769
15	4.154
20	5.538
25	6.923
30	8.308
35	9.692
40	11.077
45	12.462
50	13.846
55	15.231
60	16.615
65	18.000

AFTER

Feed Gas	Flow Solvent
MMSCFD	BPD
10	2.308
15	3.462
20	4.615
25	5.769
30	6.923
35	8.077
40	9.231
45	10.385
50	11.538
55	12.692
60	13.846
65	15.000

Figure 12. Flow Solvent

3.5. Pressure Differential Indicator

The PDI (Pressure Differential Indicator) on the AGRU absorber unit is an indication that can be used to determine if foaming is occurring, usually in the form of an increase in PDI above 5 psig. It can be seen in the picture below that the condition before WTS implementation is carried out, there are many PDI spikes above 5 psig which indicates foaming in the AGRU system.

Figure 13. Pressure Differential Indicator (Before)

Meanwhile, after WTS implementation were carried out, the PDI indicator was relatively stable at 3-4 psig, which shows that no more foaming occurred.

Figure 14. Pressure Differential Indicator (After)

3.6. Laboratory Result

After implementing the WTS method, the particulate matter content and heavy hydrocarbon content in the Matindok CPP's solvent can be reduced, which can be seen in Figure 15 and Figure 16. The results of laboratory analysis before implementing the WTS method show the Particulate Matter Content parameter (>0.45 µm) of 73 mg/L and the Heavy Hydrocarbon Content parameter is 393 mg/L. After implementing the WTS method, there was a decrease in the value of the Particulate Matter Content parameter (>0.45 µm) to 22 mg/L and the Heavy Hydrocarbon Content parameter to 60 mg/L.

CERTIFICATE OF ANALYSIS

Before

CLIENT : PT PERTAMINA EP
SAMPLE SGS ID : 04.OGC22.0357
SAMPLE TYPE : FORMULATED SOLVENT (AMINE
SAMPLE NAME : LEAN AMINE
LOCATION : DONGGI MATINDOK FIELD

################ 21 MAR 2022
ANALYSIS DATE : 21-26 MAR 2022
SAMPLING DATE : NOT AVAILABLE
SAMPLING TIME : NOT AVAILABLE
SAMPLED BY : CLIENT

THE FOLLOWING RESULTS WERE OBTAINED:

No.	Parameter of Analysis	Unit	Method	Specification		Result
				Min.	Max.	
1	Water Content	%-M/M	ASTM E203-16	-	-	41.33
2	Piperazine (Active) Content	%-M/M	SGS INH-Volumetric Titration	-	-	2.76
3	aMDEA Content	%-M/M	SGS INH-Volumetric Titration	-	-	40.77
4	Total Amine Content (Piperazine + aMDEA)	%-M/M	Calculation	-	-	43.53
5	Sulfolane Content	%-M/M	Calculation	-	-	14.92
6	H_2S Gas Loading	mol/mol	DOW HS103	-	-	0.0018
7	CO_2 Gas Loading	mol/mol	DOW HS103	-	-	0.0023
8	Total Acid Gas Loading (H_2S + CO_2)	mol/mol	Calculation	-	-	0.0041
9	Heat Stable Amine Salts Content (HSAS)	%-M/M	DOW HS103	-	-	0.19
10	Particulate Matter Content (>0.45 µm)	mg/L	ASTM D5907-18	-	-	73
11	Heavy Hydrocarbon Content	mg/L	ASTM D7066-04(2017)	-	-	393
12	Dissolved Carbon Number Distribution	-	-	-	-	*Refer to page no. 4*
13	Chloride Content	mg/L	SM 4500-Cl:2021	-	-	31
14	Sodium Chloride Content	mg/L	SM 4500-Cl:2021	-	-	80

Figure 15. Laboratory Result Before WTS Implementation

CERTIFICATE OF ANALYSIS

CLIENT : PT PERTAMINA EP
SAMPLE SGS ID : 08.OGC22.0829
SAMPLE TYPE : FORMULATED SOLVENT (AMINE)
SAMPLE NAME : DONGGI AMINE SAMPLE
LOCATION : DONGGI MATINDOK FIELD

After

SAMPLE RECEIVED : 26 AUGUST 2022
ANALYSIS DATE : 26-31 AUGUST 2022
SAMPLING DATE : NOT AVAILABLE
SAMPLING TIME : NOT AVAILABLE
SAMPLED BY : CLIENT

THE FOLLOWING RESULTS WERE OBTAINED:

No.	Parameter of Analysis	Unit	Method	Specification		Result
				Min.	Max.	
1	Water Content	%-M/M	ASTM E203-16	-	-	30.05
2	Piperazine (Active) Content	%-M/M	SGS INH-Volumetric Titration	-	-	3.66
3	aMDEA Content	%-M/M	SGS INH-Volumetric Titration	-	-	46.70
4	Total Amine Content (Piperazine + aMDEA)	%-M/M	Calculation	-	-	50.36
5	Sulfolane Content	%-M/M	GC FID	-	-	18.91
6	Monoethanolamine Content	%-M/M	GC FID	-	-	0.0045
7	H_2S Gas Loading	mol/mol	DOW HS103	-	-	0.0035
8	CO_2 Gas Loading	mol/mol	DOW HS103	-	-	0.0053
9	Total Acid Gas Loading ($H_2S + CO_2$)	mol/mol	Calculation	-	-	0.0088
10	Heat Stable Amine Salts Content (HSAS)	%-M/M	DOW HS103	-	-	0.818
11	Particulate Matter Content (>0.45 µm)	mg/L	ASTM D5907-18	-	-	22
12	Heavy Hydrocarbon Content	mg/L	ASTM D7066-04(2017)	-	-	60
13	Dissolved Carbon Number Distribution	-	-	-	-	**Refer to page no. 4*
14	Chloride Content	mg/L	SM 4500-Cl:2021	-	-	89
15	Sodium Chloride Content	mg/L	SM 4500-Cl:2021	-	-	226

Figure 16. Laboratory Result After WTS Implementation

Before this program was implemented, there was potential for H_2S gas to be released into the air due to the reaction from burning H_2S when the flare reached >15 MMSCFD, and there was a potential for gas release through the flaring process of >2 MMSCFD when the production cut rate happened during foaming event. After improvements are made to the well switching method, the hydrocarbon level in the Separator is relatively stable at 17% and the quality of the gas sales are well maintained as well as no foaming events occurred.

3.7.Resin Reduction and Hazardous Waste Reduction

Reducing the use of solvents affects the generation of solvent packaging waste. In the period before the program was implemented, solvent use was recorded at 2,769 BPD. After the program was implemented, solvent use decreased and reached an average value of 2,308 BPD. The following table is the record of solvent consumption:

Table3. Resin Consumption

Chemical	Units	Before WTS	After WTS
Flow Amine	BPD	2,769	2,308
Solvent	Liter/day	440,235.8	366,942.7

Table4. Difference of Hazardous Waste Generation Before and After Implementation of WTS

Year	Gas Production (TOE)	Flow Solvent (BPD)	Amine	Hazardous PackageWaste (ton)	Hazardous packaging waste reduction (Ton)	Solvent Usage Difference (BPD)
2021	917,932.71	2,769		10.11	1.56	461
2022	921,578.94	2,308		8.56		

Based on table 4, gas production in 2021 was 917,932.71 TOE and gas production in 2022 equal to 921,578.94 TOE. While gas production is increased, DonggiMatindok Field can reduce the generation of hazardous packaging waste with a reduction amount of 1.56 tonnes.

3.8. Economic Benefit

Referring to the Contract Agreement of PT Pertamina EP Asset 4 DonggiMatindok Field with PT. Mitra Tata Lingkungan Baru (as hazardous waste transporter) under Contract Number 3900516815. Hazardous waste transport costs are as follows:

1 Truck = 80 Drums (200 L)

Transport costs = IDR 130,000,000

Processing unit price = IDR 4,750,000

Total Savings in 2022 earned

= (Transportation costs x unit price) + (truck requirements x reduction in generation in 2022)

= (IDR 130,000,000 x 2) + (IDR 4,750,000 x 1.56)

= IDR 267,388,761

This program has succeeded in reducing the generation of hazardous materials packaging waste, thereby reducing the costs of transporting and managing the generation of hazardous waste sent to third party. In addition, through the implementation well test solvent, the company is able to eliminate gas sales losses due to foaming with a total efficiency of IDR 140,600,699,739.50 and a reduction in hazardous waste handling costs of 1.56 tons, equivalent to savings of IDR 267,388,761.

4. Conclusions

Through the WTS method and HYSYS simulation results, solvent flow for feed gas variations has been obtained which is smaller than the previous base design. From laboratory results tested on 21 – 26 March 2022 before the WTS method was applied, the Heavy Hydrocarbon Content parameter was 393 mg/L and Particulate Matter Content (>0.45µm) was 73 mg/L. After implementing WTS using the well switch method with gradual valve opening from 0% - 25% -

50% - 75% - 100% and held for 30 minutes at each stage. Obtaining the results of setting the flow of amine solvent for variations in feed gas which is smaller than the previous base design and laboratory results tested on 36 - 31 August 2022 have lower Heavy Hydrocarbon Content parameter values, namely 60 mg/L and Particulate Matter Content (>0.45 µm) of 22 mg/L. The foaming event at the Matindok CPP was resolved and the DonggiMatindok Field was able to operate normally, namely at sales of 87 MMSCFD and was even able to distribute gas sales of 105 MMSCFD safely without foaming occurring.

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