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Optimization of Flow Rate TEG (Triethylene Glycol) in Absorbing Water Levels in Glycol Contactor (V-5400) With ASPEN HYSYS Simulation

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Abstract

The purpose of this research is to determine the amount of TEG flow rate required to get dry gas with a moisture content consistent with industry requirements and to determine how much water content is absorbed in dry gas after TEG flow rate optimization. The glycol contactor (V-5400) is the primary piece of equipment for this activity, and the materials are dry gas and TEG solution in the dehydration unit. The research method employed is descriptive quantitative simulation via the use of the Aspen HYSYS V8.8 application tool. According to the simulation findings on the glycol contactor (V-5400) using Aspen HYSYS, in order to get dry gas with a moisture content of 4-7 lb/MMscf, a TEG solution with a flow rate of 2.4 ft3/min and a water content of 2.4 ft3/min is required. absorbed following flow rate optimization TEG is used to convert 7.6026 lb/MMscf water content to 6.7881 lb/MMscf water content with a percentage difference of 0.8145, but real data converts 7.4702 lb/MMscf water content to 6.6984 lb/MMscf water content with a percentage difference of 0.7718.

Introduction

Natural gas, also known as natural gas liquids, has a chemical makeup that is similar to that of crude oil, but is simpler. It is made up of a variety of compounds whose primary constituents are hydrogen atoms (H) and carbon atoms (C), and it is sometimes referred to as hydrocarbon compounds informally. Starting with C1 (methane) and progressing to C4 (butane), there is also C5+ (pentane and heavier ones) which exists in liquid form as condensate and may be found in the atmosphere. With an absorption process, natural gas is dehydrated in a dehydration unit in a glycol contactor device (V-5400), and the process is continuously monitored and recorded. It is the absorbent substance that is used in this operation that is known as TEG (Triethylene glycol). There are a variety of elements that influence the dehydration of natural gas during the processing step. The flow rate of the TEG that is being used is one of the most significant factors to consider. They have an effect on the quantity of water present in the natural gas that is generated by the glycol contactor.

Oil and natural gas companies must take into consideration the moisture content of dry gas, which is one of the most important features of the fuel. If dry gas is provided to industrial users, the moisture content of the dry gas supplied to them is limited to a maximum of 7 lb/MMscf for dry gas sent to consumers. Hydrates will develop if the high-water content in dry gas is allowed to continue for an extended period of time (Greaves et al., 2008; Melchuna et al., 2016).

The longer the hydrates stay in place, the more problems will occur during operation, and the lower the selling price and economic value of the gas will be in the long run. We predict that decreasing the amount of water present in natural gas will increase its calorific value while also making its operation easier and lowering the likelihood of damage to any equipment used in its operation (Bolland, 2013).

In order to determine the quantity of water contained in natural gas, the technique known as gas chromatography (GC) is utilized. However, with time, the Gas Chromatography apparatus loses its ability to function properly, making it hard to maintain adequate control over the water content. As a consequence, a different technique, precisely modeling the operating conditions of the glycol contactor (V-5400) utilizing Aspen HYSYS, may be employed to get the appropriate results. Following the results of a computer simulation carried out using Aspen HYSYS, it has been found that the water content in the glycol contactor (dry gas) output gas exceeds the maximum permissible level. A result of the research, a glycol contactor (dry gas) output gas with a standard water content was obtained by the use of one of the important elements, namely the TEG flow rate, to achieve a standard water content in the output gas was obtained.

Methods

The study method employed is descriptive quantitative simulations to determine a basic system description by manipulating and controlling the system to determine its impact. The purpose of this study was to get dry gas with a moisture content consistent with established requirements after dehydration at the glycol contactor (V-5400) using the Apen HYSYS V8.8 application software and the Glycol Package. The rationale for adopting the Glycol Package is that it makes use of TST (Twu-Sim-Tassone) EOS to more correctly and consistently identify the phase behavior of a combination of TEG and water. Additionally, a review of the literature from many publications and prior studies was undertaken. The information was gathered via direct conversations with operators. The primary data includes the actual state of wet gas, TEG solution, dry gas, and rich TEG as they are being produced by the glycol contactor (V-5400) dehydration unit. Secondary data is collected in the form of; (1) Natural gas data acquired from the control room operator; and (2) Water data gained from the control room operator. (2) The TEG solution data acquired from the control room operator is shown below. In Badak field, the specifications and operational data of a glycol contactor (V-5400) dehydration unit were collected and analyzed. This information is acquired from the operator in the control room. The first stage is to gather all data (design and actual) and process steps on the dehydration unit, particularly on the glycol contactor (V-5400), in a systematic and logical way in order to generate a simulation that is near to reality. Validate the software's usage by ensuring that the simulation error remains within the tolerance limit. After validating the simulation results, a case study is conducted on the problems encountered in the field, specifically that the water content of the glycol contactor output gas (dry gas) does not meet the standard, necessitating optimization using one of the influential variables, namely flow rate TEG.

Results and Discussion

Validation of the Simulation Approach Used

Table 1. Simulation validation based on design data

Parameter Stream	***Inlet stream***		***Outlet stream***				***% Error***	
			Data Design		**Simulation**			
	Wet gas	**TEG**	***Dry gas***	***Rich*** TEG	***Dry gas***	***Rich*** TEG	***Dry gas***	***Rich*** TEG
Temperature (^{0}C)	31,67	46,11	31,63	32	31,67	31,66	0,0012	0,0106
Pressure (kPa)	5066	5066	5066	5066	5066	5066	0	0
Molar Flow (kgmol/h)	2630	0,02305	2630	0,0305	2630	0,03049	0	0,0003

Source: Secondary data

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Table 2. Simulation validation based on actual data

Stream Parameters	***Inlet stream***		***Outlet stream***				***% Error***	
			Actual Data		**Simulation**			
	Wet gas	TEG	***Dry gas***	***Rich*** TEG	***Dry gas***	***Rich*** TEG	***Dry gas***	***Rich*** TEG
Temperature (^{0C})	32,16	47	32,17	32,65	32,13	32,13	0,0012	0,0159
Pressure (kPa)	5070	5067	5066	5066	5066	5066	0	0
Molar Flow (kgmol/h)	2631	0,02326	2631	0,0306	2631	0,03038	0	0,0071

Source: Primary data, 2020

Starting with the building of a real-world system model, the simulation technique may be used. When modeling a system, it is important to illustrate how the different components interact with one another in order to accurately represent the behavior of the system. Following the creation of the model, the model is converted into a computer program that may be used to simulate the model. The results of the simulation are checked when the model has reached convergence. Validation is accomplished by comparing the simulation results with data from plant tests. Harrel (2003) provides an explanation of validation, which states that the simulation model developed must be trustworthy.

The model validation process demonstrates that the simulation model provides a reliable representation of the actual system. When a model is validated, it means that it has been determined to be a meaningful and correct conceptualization or abstraction of a real-world system, or both. As a result, validation is an effort to determine whether or not the model is a genuine representation of the world under investigation and whether or not it can provide persuasive results. Because this study was carried out using a simulation software, it is vital to compare the design data and real data obtained from the experiment with the simulation findings.

The output of the glycol contactor (V-5400) was tested using design data and real data, and the findings were compared to those obtained via simulation. Based on the results of the comparative analysis of the glycol contactor output (V-5400) based on the design data and the actual data with the simulation results shown in Tables 1 and 2, it can be concluded that the modeling is valid and almost identical to the actual condition, with a small percent error obtained. real operation, in order for the simulation that has been created to be put to use.

Composition of Glycol Contactor Output Gas (Dry gas) Simulation Results

Table 3. The composition of *glycol contactor* (*dry gas*) output gas

No.	**Component**	**Composition (Mole fraction)**	
		Design Data	**Actual Data**
1.	CO_2	0,0555	0,0555
2.	N_2	0,0007	0,0007
3.	C1	0,8305	0,8305
4.	C2	0,0509	0,0509
5.	C3	0,0348	0,0348
6.	IC4	0,0072	0,0072
7.	NC4	0,0090	0,0090
8.	IC5	0,0033	0,0032
9.	NC5	0,0021	0,0021
10.	C6+	0,0059	0,0059

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11.	H_2O	0,0002	0,0002
12.	$C_6H_{14}O_4$	0	0
Total		1	1

Source: Primary and secondary data

PT. Pertamina Hulu Sanga-natural sanga's gas has a high water content; as a result, the gas will be delivered to PT. Badak LNG, where it will be converted into LNG (Liquid Natural Gas) and LPG (Liquefied Petroleum Gas) for sale (Liquified Petroleum Gas). Natural gas must first be dehydrated before it can be transported to its final destination. The goal of this procedure is to minimize the amount of water present in natural gas in order to meet the requirements that have been established (Brathen & Audun, 2007).

As shown in Table 4.3, the water content in the glycol contactor (dry gas) output gas is calculated using design and actual data in mole fraction units, respectively, based on design data and actual data in mole fraction units, respectively. The data is then transformed using a method to indicate the water content in pounds per million cubic feet of air (lb/MMscf). The simulation results show that the water content in glycol contactor output gas (dry gas) is 7.6026 lb/MMscf for the design data and 7.4702 lb/MMscf for the actual data, indicating that the water content contained in glycol contactor output gas (dry gas) exceeds the predetermined standard, necessitating the need to conduct an optimization study using one of the influential variables, namely, the flow rate of TEG used. Once the simulation results are.

This can be caused by the TEG flow rate in the glycol contactor (V-5400) being disproportionate or not proportional to the amount of water vapor present in natural gas, resulting in a water content in natural gas that exceeds the standard that has been established. In addition, the lack of use of TEG can result in a water content in natural gas that is significantly higher than the standard. Consequently, the flow rate of TEG must be raised to a level suitable to absorb the water content of natural gas, allowing the water content to be lowered to a level consistent with a set norm. To compensate for the quantity of pollutants absorbed, an increasing number of absorbents are required, according to Bagus (2017), to be capable of absorbing contaminants in the process gas and therefore compensating for the amount of impurities ingested. The absorbent will soon saturate if the increase in the flow rate of the absorbent is not counterbalanced by an increase in the flow rate of the absorbent. This will result in the absorbent being unable to absorb contaminants in the process gas. The increase in the flow rate of the process gas entering the contactor must be counterbalanced by an increase in the flow rate of the absorbent entering the contactor.

Optimization of TEG Flow Rate in Absorbing Water Content in Glycol Contactor (V-5400)

Table 4. Water content in *glycol contactor* (*dry gas*) output gas is optimized using TEG *flow rate*

No	***Flow rate* TEG (ft3/min)**	**Water Content**			
		Design Data		**Actual Data**	
		Mole fraction	Lb/MMscf	Mole fraction	Lb/MMscf
1	0,3	0,0002	7,6026	0,0002	7,4702
2	0,6	0,0002	7,4955	0,0002	7,3685
3	1,2	0,0002	7,2595	0,0002	7,0757
4	1,8	0,0001	7,0238	0,0001	6,9217
5	**2,4**	0,0001	**6,7881**	0,0001	**6,6984**

Source: Primary and secondary data

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Table 5. The moisture content absorbed in the glycol *contactor* output gas (*dry gas*) optimization results using flow *rate* TEG

No	***Flow rate* TEG (ft3/min)**	**Percentage Difference**	
		Design Data	**Actual Data**
1	0,6	0,1071	0,1017
2	1,2	0,3431	0,3945
3	1,8	0,5788	0,5485
4	**2,4**	**0,8145**	**0,7718**

Source: Primary and secondary data

With the help of Aspen HYSYS (Hypotectical System) simulation, this research investigates how to optimize the TEG flow rate in order to get dry gas in accordance with the standard on the glycol contactor (V-5400). To determine the flow rate point required to ensure that the glycol contactor (dry gas) output gas had a water content that was in compliance with established standards, and to determine how much water content was absorbed after optimization of the TEG flow rate, variations of the TEG flow rate were used in this study. used.

The findings of this research suggest that the water content in natural gas will decrease the more flow rate TEG is used, and vice versa, the water content in natural gas will increase the less flow rate TEG is used, according to the findings. According to the findings of Campbell, (1992) journal study, the bigger the TEG mass flow rate, the greater the number of TEGs that come into contact with the gas in the contactor, and the greater the amount of water that is absorbed by the contactor. Campbell (2004) further asserts that the higher the TEG flow rate, the greater the amount of water that will be absorbed by the plant.

According to Istadi (2012), the flow rate of glycol is determined by the quantity of water that has to be removed from the solution. A flow rate that is too low will result in a reduction in the quantity of water that is absorbed, and the purity of lean glycol has a significant impact on the rate of water vapor absorption (Harmiyanto, 2013). When the quality of lean glycol is poor, the absorption of water is diminished. In general, the higher the concentration of lean glycol, the greater the amount of water that is absorbed. It is common practice to utilize lean glycol, which has a concentration ranging from 97 to 99 percent, while the glycol that comes out of the contactor has a concentration ranging from 80 to 90 percent. In the instance of the glycol contactor discovered at PT. Pertamina, on the other hand, when compared to optimization utilizing the TEG flow rate that was employed, Hulu Sanga-sanga has little influence, and the water content in natural gas stays over the specified threshold.

Dry gas had 7.6026 lb/MMscf of moisture before optimization for design data, whereas actual data included 7.4702 lb/MMscf of moisture before optimization. Results showed that the flow rate optimization of TEG and its influence on the water content in the glycol contactor (dry gas) output gas could be achieved, as discovered by the researchers. For TEG with a flow rate of 0.6 ft3/min, the water content for the design data is 7.4955 lb/MMscf, resulting in a percentage difference of 0.1071; however, the water content for the actual data is 7.3685 lb/MMscf, resulting in a percentage difference of 0.1017. Water content for the design data is 7.2595 pounds per million cubic feet (MMscf), however the water content for the actual data is 0.3431 pounds per million cubic feet (MMscf), resulting in a percentage discrepancy of 0.3431 pounds per million cubic feet (MMscf). The water content is 7.0757 lb/MMscf, with a percentage difference of 0.3945, indicating a difference of 0.3945 percent. Water content of 7.0238 lb/MMscf can be produced using design data with a percentage difference of 0.5788, whilst water content of 6.9217 lb/MMscf can be produced using real data with a percentage

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difference of 0.5485 using TEG with a flow rate of 1.8 ft3/min. In the case of TEG with a flow rate of 2.4 ft3/min, the residual water content in this situation for the design data is 6.7881 lb/MMscf, which is a variation of 0.8145 percentage points from the design data. When utilizing real data, the water content is 6.6984 lb/MMscf, with a percentage difference of 0.7718 compared to the theoretical value.

According to the study that has been done, the TEG flow rate of 2.4 ft3/min is sufficient to achieve the desired water content in the glycol contactor (dry gas) output gas in accordance with the standards. Following the completion of the optimization of the TEG flow rate using the Aspen HYSYS simulation, it was discovered that the dry gas content for the design data was 6.7881 lb/MMscf with a percentage difference of 0.8145, while the moisture content for the actual data was 6.6984 lb/MMscf with a percentage difference of 0.7718. As shown in Table 2.4, the standard for dry gas specifications states that the maximum limit for water content (H2O) in the dry gas composition is 7 lb/MMscf. Therefore, the gas output of the glycol contactor (dry gas) complies with the set criteria for dry gas (Campbell, 2004).

Although gas chromatography is often used to monitor the composition of natural gas, in the event that the instrument fails, a simulation software such as Aspen HYSYS may be temporarily utilized to determine the composition of natural gas. The corporation monitors and manages the impurities that interfere with the process on a regular basis, one of which is the water content, to ensure that the gas supplied and delivered to customers complies with the standards or requirements that have been established.

The flow rate of TEG is one of the most important elements influencing the amount of water present in the glycol contactor output gas (Carroll, 2003). As is well known, water content in natural gas is a very undesirable impurity that should be avoided at all costs. On the basis of the information obtained, it is preferable for future research to analyze any problems that may arise during the dehydration process using a glycol contactor, one of which is the point at which the hydrate will form based on the dew point of natural gas, which can be determined using the Aspen HYSYS simulation.

If it is discovered that there is water content in natural gas at the dew point and that the temperature conditions at that time are cold enough, the free water will freeze and form hydrates in the pipe, which will cause blockages in the pipe and interfere with the process if left in for an extended period of time.

Conclusion

A TEG with a flow rate of 2.4 ft3/min and a moisture content for design data of 6.7881 lb/MMscf is required to produce glycol contactor (dry gas) output gas with a standard moisture content of 4-7 lb/MMscf. The actual moisture content is 6.6984 lb/MMscf. According to design data, the water content absorbed on the glycol contactor (V-5400) after optimization of the TEG flow rate decreased from 7.6026 lb/MMscf to 6.7881 lb/MMscf, representing a percentage difference of 0.8145, whereas actual data decreased from 7.4702 lb/MMscf to 6.6984 lb/MMscf, representing a percentage difference of 0.7718.

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