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Assessment of Diethylene Glycol (Deg) Dehydration System in a Natural Gas Processing System

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Abstract

The natural gas found in Nigeria's Obagi field, specifically in OML 58 where the Obite gas processing plant is located, typically contains water vapour. It is generally assumed that about 98% of gas discoveries in this area are saturated with water. The presence of water in either liquid or vapour form creates technical challenges. This problem is prevented through dehydration to prevent hydrate formation. To achieve optimal production, cost-effectiveness, and improved marginal gains in gas processing, dehydration systems need to be carefully evaluated. This paper offers the use of a simulation tool to tackle the natural gas dehydration system at the Obite Gas Plant. Process conditions of 84bar and 35°C and gas flow rate of 8MMSCFD, as the input data. Results indicate a DEG flow rate of 12.735m³/h, the water volume was reduced to 2.3915lb/MMSCF from an early value of 9.92lb/MMSCF. This is below the pipeline specification. The volume of methane recovered with a flow rate of 74%, for a DEG flow rate of 2.4m³/h, 4.6lb/MMSCF of water recovered in the gas stream. DEG dehydration can be used for dehydration systems due to its ability to meet low temperature and dew point specifications, and low initial and operating costs. After investigating various dehydration units at Obite gas processing facility, it is apparent that DEG can be used alongside TEG and many of the problems encountered and costs incurred could have been prevented with a better engineering understanding of the dehydration system.

Keywords: Evaluation, Natural Gas, Processing, Dehydration, Diethylene glycol

1.0 Introduction

Gas is any substance that boils at atmospheric pressure and any temperature between the absolute zero of outer space through some 40 to perhaps 80^{0}F (4.426.7^{0}C) (CO Wosu, EM Ezeh 2024). Department of Transportation (DOT) (Glasier, CH. 1981) definition of gas reads any material or mixture having in the container an absolute pressure exceeding 40 psi (pound per square inch) at 70^{0}F (21.1^{0}C), having an absolute pressure exceeding 104psi at 130^{0}F (717Kpa at 54.4^{0}C), or any liquid flammable material having a vapour pressure exceeding 40psi absolute at 100^{0}F (275.8 Kpa at 37.8^{0}C) as determined by ASTM (American Society For Testing and Materials) Test D-323.

Natural gas- a combustible gas that occurs in the porous of the earth's crust and is found with or near accumulation of crude oil. Being in gaseous form, it may occur alone in separate reservoirs. More commonly it forms as a gas cap or mass of gas, entrapped between liquid petroleum and impervious capping rock layer in a petroleum reservoir. Under conditions of greater pressure, it is intimately mixed with or dissolved in crude oil (Mc-Graw Hill (1992). Typical natural gas consists of hydrocarbons having a very low boiling point mainly C1-C9 hydrocarbon. Natural gas "Fuel of the future or fuel for the 1990's" is the way many in the industry are labelling natural gas. It is a clean burning, relatively abundant fuel, and this has made it very attractive in this "age of the environment" (Guo and Ghalambor 2005). It has been used for a long time as a residential fuel and boiler fuel for industry and utilities. And now a concentrated effort is being made to adopt it as a transport fuel. If it became an economic transport fuel, it would surely become the fuel for the 1990s and the fuel for the future.(Ezeh, & Wosu 2024). The growing worldwide concern for the environment is very favourable for natural gas. Nevertheless, Natural gas is a mixture, is variable, has weight, is compressible, is expansible, is soluble in crude oil, occurs in various forms, contains water vapour, is hydrate forming, has heat value, may carry impurities and is hazardous (Etuk 2007). Water vapour is present in practically all natural gas streams as it comes from the well. In many cases, liquid water in droplet form is also entrained. The gas-producing zone of a reservoir tends to contain more water vapour and less liquid or free water than the oil-producing zone. Water vapour is probably the most common impurities found in untreated natural gas. (Guo, et al 2007).

The dehydration of natural gas is the removal of the water that is associated with the natural gas in the vapour form (Ezeh,& Nwosi (2024). The amount of water in a gas at equilibrium conditions depends upon the pressure and temperature. This saturation temperature at the specified pressure is the dew point of the gas. At the dew point, natural gas is in equilibrium with liquid water. Keeping the volume and pressure constant on a water vapour-saturated gas, water will condense out at a lower temperature since the capacity of gas to hold water is less (Abdel et al 2003). The same is true if the volume and temperature are kept constant but the pressure is allowed to increase. Keeping the volume and pressure constant on a water vapour-saturation gas while lowering the dew point temperature is known as dew–point depression.
This term indicates to what extent the moisture content of a gas may be lowered. To avoid the condensation of water at lower temperatures, the dew point of the gas stream is depressed. To illustrate the concept of dew point depression, assume that natural gas at 500psia and 60^0F at the saturation point contains 30 lbm of water per 1 MMcf. The dew point of this gas is 60^0F. Suppose this natural gas is transported by pipeline at 20^0F, the saturation point will then be 7 lbm if water/MMcf. The original 30 lbm of water, if left in the gas, will exist in the form of 7 lbm of water vapour and 23 lbm of free water/MMcf, if the pressure remains the same. This free water is a potential source of hydrates to form and plug the line. Suppose the natural gas is processed in a dehydration unit, and the dew point is depressed to 50^0F, this means that no free water will exist in the gas until the temperature goes to 10^0F or lower. Gas at 500 psi and 10^0F contains about 5lbm of water-vapour/MMcf. The dehydration unit must be designed to remove 25 lbm of water from each MMcf of gas to achieve the 50^0F dew point depression.
There are essentially four methods in current use for dehydrating gases: Direct cooling, Compression followed by cooling, Absorption and Absorption. The presences of water in a liquid or vapour state create problems in the smooth flow of natural gas through pipelines. Its presence results in: Freeze-ups due to ice of hydrate formation. Corrosion with subsequent dirt troubles, particularly if the gas stream contains CO_2 and H_2S. Condensation causes slug flow conditions and reduced line capacity due to accumulation and reduction in the calorific value of natural gas as a result of a decrease in heating value.

Dehydration is the removal of water from a substance. Dehydration may be accomplished by the use of solid substances such as those used in dry-bed dehydrators; or a liquid, such as triethylene glycol, diethylene glycol, or Monoethylene glycol, may be employed; or a gas may be used, such as striping gas in a triethylene glycol (TEG) or Diethylene Glycol (DEG) re-boiler or diethylene glycol. The more common hydrate inhibitors are methanol and ethylene glycol. Most natural gas facilities examined use only one or more of the following; Glycol (ethylene glycol) injection, TEG (triethylene glycol) dehydration or dry-bed dehydrators. Dry bed dehydration is an adsorption process, while the TEG, dehydration system removes the water from the gas by absorption process (Ghalambor, et, al. 2007).

Diethylene Glycol (DEG) is a glycol used in natural gas dehydration systems, although it is not popular when compared to Triethylene Glycol (TEG). DEG is selected for specific cases based on its properties and is generally used in systems operation of very low temperatures or specific gas compositions. The most vital properties of Diethylene Glycol (DEG) include its absorption capacity: DEG can effectively absorb water from natural gas, although its absorption capacity is slightly lower than TEG hence it is sometimes recommended to be used in areas where TEG becomes too expensive. Other critical properties consist of a Lower Boiling Point: DEG has a lower boiling point than TEG (around 245°C compared to TEG’s 287°C), making it less thermally stable in high-temperature systems. Lower Viscosity: DEG's lower viscosity compared to TEG can make it preferable in systems with lower operating pressures or where ease of circulation is important. Cost: DEG is generally less expensive than TEG, making it an attractive choice for certain lower-cost operations. Applications: DEG is typically used in situations where: - The gas stream contains lower water content - There are moderate temperature and pressure conditions. (Ikoku, Chi. 1992).

The natural gas is found in Nigeria's Obagi field, specifically in OML 58 where the Obite gas processing plant is located. The Obite Gas Processing Plant, located in the Ogba/Egbema/Ndoni Local Government Area (ONELGA) of Rivers State, Nigeria, plays a crucial role in the oil and gas industry, particularly in the processing of natural gas and associated gas from oil exploration activities in the region. This area is part of Nigeria's Niger Delta, rich in oil and natural gas reserves, and hosts various oil and gas production facilities. With regards to Gas Processing Capacity, the Obite Gas Processing Plant is designed to process both natural gas and associated gas (gas produced alongside oil). The facility has a large processing capacity, handling millions of standard cubic feet per day (MMscf/d) of gas. The processed gas is essential for domestic consumption and export, especially through Nigeria's gas pipeline network.

Dehydration and Compression, the Obite Gas Processing plant incorporates advanced dehydration units to eliminate water from the natural gas, preventing pipeline corrosion and other operational issues. Compression units are equally crucial as they ensure the gas is pressurized to the levels required for transportation through pipelines. Gas Liquids Recovery: the plant can recover valuable natural gas liquids (NGLs) such as propane, butane, and condensate. These NGLs are essential for producing liquefied petroleum gas (LPG) and other industrial products. Pipeline Connections: this plant includes the Nigerian Gas Pipeline Network and potentially the Nigeria Liquefied Natural Gas (NLNG) facilities, enabling the transport of processed gas for both domestic consumption and export, supporting Nigeria's goal of monetizing its gas resources. Ownership and Operatorship, the plant is part of the joint venture between Total Energies Nigeria Limited and the Nigerian National Petroleum Corporation (NNPC). Total Energies operates the plant as part of its wider network of oil and gas facilities in the Niger Delta. The plant was conceptualized and developed to harness the large volumes of gas produced from oil fields in ONELGA. (Ahmad 2009).

Most natural gas carries substantial quantities of water at the time it is produced from the well. Excess water in natural gas leads to the formation of hydrates and the freezing of the line. Gas hydrates were first discovered in 1810. (Carson, D.B and Katz D.L 1943) Gas hydrates are chemical compounds of gas and water similar to hydrated salts of inorganic compounds. Copper sulphate ($CuSO_4.5H_2O$) and Calcium Sulphate ($CaSO_4.2H_2O$) are examples of such salts. All handlers of natural gas are familiar with the phenomenon of the line "freezing up". At first, this freezing was thought to be the result of the freezing of water alone in the gas. It was found however that some hydrocarbon vapours combine to form a snow-like substance called hydrates. These hydrates may be formed at temperatures well above the freezing point of water, under suitable pressure conditions.

A clear realization that natural gas pipeline freezing was caused by hydrate formation resulted in the publication of Tests, (Mc Ketta, J.J and Wehe A.H. 1958) conducted at the Texoma Gas Company, gas cooling plant at Fritch, Texas. This plant was built to cool (to 40^0F) natural gas for pipeline transmission to Chicago. Cooling to that temperature was expected to reduce the gas dew point sufficiently to prevent any condensation in the line, yet gas passages were found coated with ice. The approximate conditions of pressure and temperature under which the hydrates form. The data cannot be completely accurate for any particular natural gas, since the hydrate points not only vary as the temperature under different pressures; they also vary following the composition of the gas at 1500 si for example, hydrates will form in typical gas at a temperature of about 70^0F. At 3000 psi the hydrated point rises to about 85^0F. In some fields hydrates form in the tubing and wellhead, requiring the application of heat "down the hole" to keep the well from freezing up. In many gas fields, however, the temperature of the gas at the wellhead ranges above 100^0F. Temperatures as high as 150^0F, are not uncommon. As the temperature goes up, the pressure at which hydrates form also rises (Ahmad Syahrul Bin Mohamad, 2009). The hydration problem, therefore, does not usually start until the gas emerges from the Christmas tree. The one final and sure way to dispose of the hydrate problem is the removal of the water vapour from the natural gas. Water is one of the requisites for hydrate formation.

2.0. Materials and Method

The paper utilized a powerful simulation tool (HYSYS), a process simulation software, for the simulation of the natural gas dehydration plant to achieve specific objectives. The software's case study package was employed to apply various quantities and flow rates of Diethylene Glycol (DEG) to the plant to assess the removal of different amounts of water. Process Overview of OGP Gas Treatment Plant, the OGP Gas Treatment Plant, operated by Total Energy, is situated in Nigeria's South-South Niger Delta, an area renowned for its oil wealth. Raw high-pressure gas is obtained from more than 25 wells with the Obagi field including Ibewa, Ogbogu and the raw gas flows through different flow lines to the Obite gas gathering station for processing before being routed through high-pressure separators, vessels 301 and 302, and then cooled in cooler fans, FB 301. Vessel 301, an inlet separator, separates the mixed gas from the manifolds, which is then sent to the cooling unit, FB 301. The recovered condensate is directed to the Obite Gas Gathering Station. The gas stream from vessel 301 passes through air cooler FB 301 to achieve a temperature of approximately 45°C. An automatic temperature monitoring and control system, a part of the Process Control System (PCS), regulates the outlet temperature. The air cooler comprises 10 fans that can be manually and independently controlled via operator stations. The high-pressure gas is then directed to heaters FC 601 A and B, where heat exchange occurs between two gas streams: the treated gas from the export gas drum (vessel 602) and the raw gas from the high-pressure separator (vessel 302). While the export gas drum stream is heated, the raw gas from the separator is cooled to around 25°C. Subsequently, the gas from FC 601 is directed to the dehydration separator vessel 601. The treated gas is then sent to the export line via a metering unit. A methanol injection point is provided in the raw gas stream before cooling to inhibit hydrate formation. The high-pressure gas undergoes further processing in the dehydration and refrigeration units, with the resulting dry gas directed to the export line leading to BONNY through the metering unit.

Table 1. Initial Raw Gas Composition Before Entering the Plant Battery Limit.

COMPONENT	MOLE FRACTION %
Methane	0.6711
Ethane	0.1268
Propane	0..085
i-butane	0.0154
n-butane	0.0254
i-pentane	0.0036
n-pentane	0.0036
n-hexane	0.0055
n-heptane	0000
n-octane	0000
n-Nonane	0000
n-decane	0000
Water	0.0034
Nitrogen	0.0087
Carbon dioxide	0.063
Hydrogen sulphide	0.00001

To produce dry gas which is suitable for pipeline transmission and for customers, natural gas must undergo a series of processing steps. These include the extraction of entrained liquids, such as hydrocarbons and water, followed by a critical dehydration phase to minimize the water vapour content. Dehydration is essential to prevent issues like hydrate formation, pipeline corrosion, and reduced gas quality. The most common dehydration method involves the use of a glycol-based system, where Diethylene Glycol (DEG) although most time triethylene glycol is used for this paper we are considering Diethylene Glycol (DEG) is employed to absorb moisture from the gas stream, ensuring it meets the required pipeline right of specifications for transport and utilization. The composition of the raw gas is key for the efficient operation of glycol gas dehydration units. Despite its extremely low concentration, hydrogen sulfide is highly toxic and corrosive. It must be removed to ensure safety and protect the integrity of processing equipment. Understanding the detailed composition of wet gas allows engineers to tailor glycol gas dehydration systems to specific gas mixtures. The selection of glycol type (typically Triethylene Glycol), circulation rates, and operating temperatures is dependent on the mole fractions of these components.

2.1 Sizing a Diethylene Glycol Dehydrator

The following are used as input data to illustrate the application of the above design procedures to an Obite Gas field gas dehydration plant. Table 1 indicates the breakdown of the key components of the raw gas composition and their respective mole fractions, which influence dehydration system performance. Despite its extremely low concentration, hydrogen sulfide is highly toxic and corrosive. It must be removed to ensure safety and protect the integrity of processing equipment. Understanding the detailed composition of wet gas allows engineers to tailor glycol gas dehydration systems to specific gas mixtures. The selection of glycol type which in this case is (typically Diethylene Glycol).

Used trayed-type contactor, select a contactor diameter with the approximate gas capacity at operating pressure. Qs for 24-in OD contactor at 1000psig = 11.3 MM scf/ d Correct for operating conditions from Tables 1 and 2. This section consists of one dehydration column of 125,000Nm^3/h design capacity. The regeneration system consists of two regenerators, each one designed for the total glycol circulation of the plant. The plant, utilizing tri-ethylene glycol as a desiccant, removes liquid water and/ or water vapours from the gas stream to prevent the formation of hydrates in the gas injection lines. A maximum gas flow rate of 101,000 Nm^3/h is foreseen during the rejection phase. Therefore, the glycol contactor works at 91% of its designed capacity. The operating conditions of the dehydration are the following:

Table 2. Operating Conditions of the Dehydration

Contactor temperature	44^{o}C
Contactor pressure	80.5kg/ cm^3
Glycol circulation	7m^3/h
Glycol circulation in lean solution	99.5%wt
Glycol concentration in rich solution	96.8%wt
Regenerator temperature	204^{o}C
Striping gas rate	160 Nm^3/h

2.2 Obite-NGL Gas Recovery Project. (NNPC/Total Energies Joint Venture)

The Obite-NGL Recovery Project is the logical offshoot of the highly successful Obite Condensate project, with a field output of about 110000 barrels per day. Online for export in the Obite -NGL Recovery Project are three distinct natural gas liquids which are heavy ends of hydrocarbon components of natural gas namely: Propane (C3), butanes (C4) and pentanes (C5+). At peak production, the NGL plant will produce 50,000 barrels per day of natural gas liquids with its feed gas coming from Obite co-mingled with other gas supplies from Total's low-pressure network tied to the Ibewa -Gas Injection Plant form. The NGL project can process approximately 600 MMscf of natural gas per day. The project has two principal locations: the offshore site at the NNPC/Total Joint Venture Oil Mining Lease (OML 58) and the onshore site at the Bonny River Terminal at Bonny, Rivers State. The terminal facilities of the project include 1600,000 barrels of refrigerated storage tanks for propane and butanes and 300,000 barrels capacity for pentanes- plus at atmospheric temperature. The life span of the project is estimated to be 25 to 30 years. The process Flow Diagram of Simulated Diethylene Glycol Natural Gas Dehydration Unit is shown in Figure 1

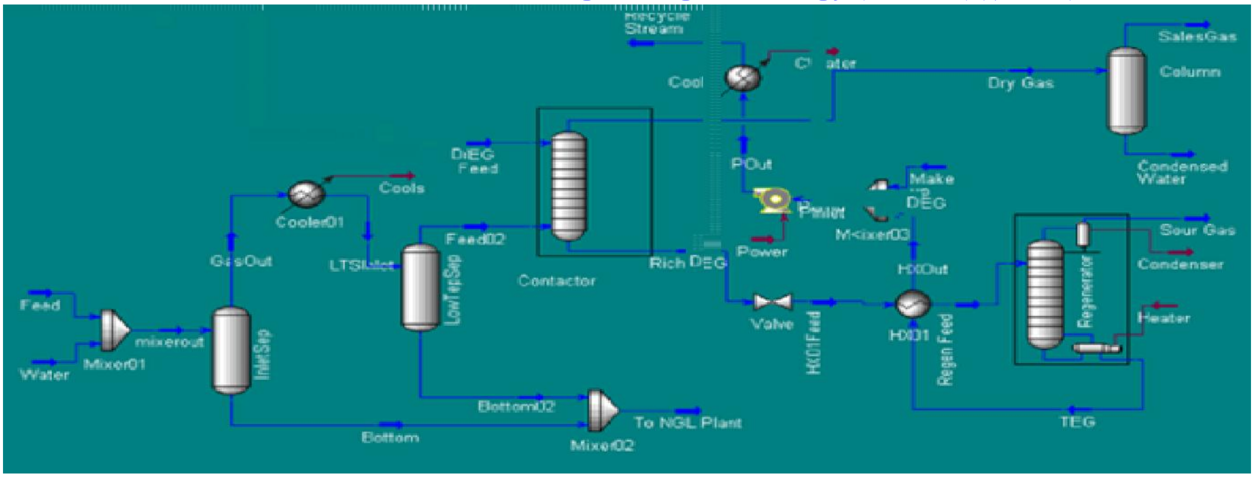

Figure 1. Process Flow Diagram of Simulated Diethylene Glycol Natural Gas Dehydration Unit

The feed composition is shown in Table 3, while the Process Conditions and Values and the Water Composition and operating condition are shown in Tables 4 and 5 respectivily. The composition, water constitutes 0.0034 per cent, which is therefore higher than the required specification of pipeline water content. Generally, 6-7lb/MMSCF is the allowable water limit for processed NG stream hence this is calculated as 6lb to 7lb of water per million standard cubic feet of processed natural gas. 100.1kgmole/h (20720 kg/h) is the Mixer Out stream flow rate and water content is 18.016kg/h (39.68lb/h). This number is more than the water specification for NG; consequently, the natural gas required processing to drop the volume of water Total E&P (1999). 50.94m^3/h of DEG was fed into the contactor to counter mix with the NG stream in the contactor. The NG flow out of the reactor as dry natural gas with a flow rate of 975.3386kgmole/h (19,949.2kg/h), of which methane has a flow rate of 796.67kgmole/h (12,780.892kg/h) and that of water is 0.01kgmole/h (0.181kg/h). The use of DEG glycol as a dehydration chemical recovered 98.9244% of methane and the composition by percentage within the dry gas stream is almost 82 percent.

Table 3. Composition of the Feed Components

Components	Composition
Methane	0.8042
Ethane	0.082
Propane	0.0248
i-butane	0.0085
n-butane	0.005
i-pentane and (C+)	0.014
Nitrogen	0.015
Hydrogen Sulfide	0.0165
Carbon Dioxide	0.03
Total	1.0000

Table 4. **Process Conditions and Values**

Process Conditions	Value
Temperature	30^{0}C
Pressure	92bar
Flow rate	10MMSCFD

Table 5. **Water Composition and operating condition**

Water Composition	Condition
Temperature	30^{0}C
Pressure	92bar
Mole Fraction	1.000
Flow rate	0.1kgmole/h

2.3 Gas Flow Rate

The main flow is downward through the bed, and high superficial velocities are based on the bed's cross-sectional area) may be used. Most designers, however, find that fewer fines and desiccant breakage occur if the rate does not exceed 1.0 to 1.5 times the maximum upward velocity predicted to prevent churning. Modifying the equation for down flow we have:

$$G = 3600\ ((C)(Pg)(P_B)(D_p)^{0\ 0.5} = A \qquad (1.)$$

Where: G = gas mass velocity (lb/hr-sq.ft); Pg = gas density lb/ft^3. Dp = particle diameter (ft); C = constant (0.81-1.06). P_B = bulk density of desiccant lb/ ft^3

3.0 Results and Discussion

Natural gas destined for the pipeline market must meet certain requirements of water vapour content. The water content is normally reduced to about 6 to 8 pounds of water per MM scf of gas. The dehydration of natural gas is the removal of the water that is associated with the natural gas in vapour form. Separation of gas and water at surface installations is accomplished in a three-part operation. First, removal of free water which is already in the liquid state, Second, condensation of a portion of the remaining water vapour by cooling the gas, and third, absorption and adsorption of remaining water vapour in suitable desiccant material in a dehydrator. Vapour may be removed from natural gas by bubbling the gas counter-current through a flow of liquid. The liquid has a special property which is called affinity for water. It attracts water. When water vapours are removed by this process the operation is called absorption. There are also solids which have an affinity for water. When gas flows through a bed of such granular solids, the water is retained on the surface of the particles of the solid material.

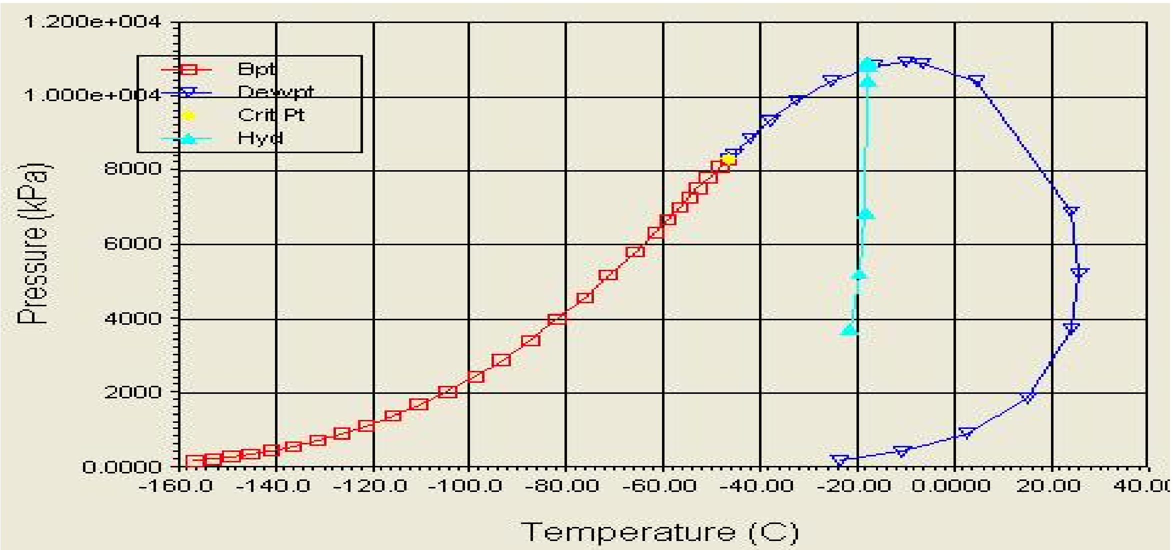

Figure 2 Hydrate Formation Phase Diagram for DEG rate of 25.47m^3/h

Figure 2 is clear evidence of the hydrate formation phase diagram for diethylene glycol at the rate of 25.47m^3/h. The NG flow out of the reactor as dry natural gas with a flow rate of 975.3386kgmole/h (19,949.2kg/h), of which methane has a flow rate of 796.67kgmole/h (12,780.892kg/h) and that of water is 0.01kgmole/h (0.181kg/h). The use of DEG glycol as a dehydration chemical recovered 98.9244% of methane and the composition by percentage within the dry gas stream is almost 82 percent.

3.1 Plots of Hydrate forming Variables with flow rate vs temperature

When the flow rate was regressed with water using the un-simulated data and the simulated data, 1b was generated. It was noticed that the un-simulated data showed a coefficient of determination (R^2) of 0.541, which was improved to 0.6809 using the simulated data. When the flow rate was regressed with temperature, the coefficient of determination for the un-simulated data was 0.4704 it improved to 0.5722 when simulated data was used.

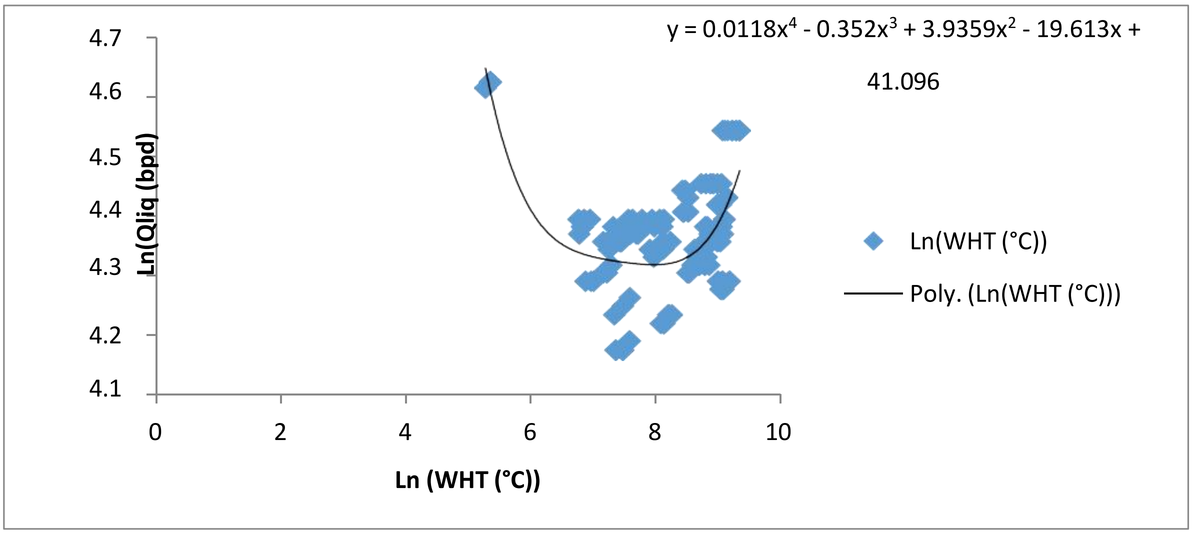

Figure 3: Scatter plot of Qliq and Temperature for Un-simulated Data sets

3.2 Developing Bubble Point Pressure Correlation

A corresponding bubble point correlation was developed for the field considered in this work using the field's fluid properties. A total of 176 data sets were utilized for this purpose. The data are the reservoir temperature, oil gravity, solution gas-oil ratio, and average gas gravity for bubble point pressure. Microsoft Excel solver was used in developing the correlation. Table 8 is the summary of the data range used in developing the new bubble point pressure correlation.

Standings 1947, developed a generalized equation for empirical bubble point pressure as shown in Equation 2. Below is the generalized equation that serves as a standard for developing this bubble point pressure correlation.

$$Pb = f\,(Rs, \overline{\Upsilon g}\,\Upsilon o, T) \qquad (2.)$$

This generalized equation serves as a standard for developing this bubble point pressure correlation. Using a non-linear multiple regression analysis, a relationship is developed. Figure 3 shows the contactor column profile of diethylene glycol, indicating the various stages, pressure, temperature Net Liquid produced, net vapour produced net feed and the net draw.

Conclusion

The technical evaluation of the Obite Gas Processing Plant's dehydration process using diethylene glycol was carried out, and the simulated results showed that diethylene glycol can be used for dehydration processes, in addition to triethylene glycol. In addition to the popular dehydration and compression processes, the advanced dehydration units at the Obite Gas Processing Plant are crucial for removing water from natural gas, which prevents pipeline corrosion and other operational issues. Compression units are equally important as they ensure that the gas is pressurized to the levels required for transportation through pipelines. Generally, natural gas from the reservoir is saturated with water, and removing water is a critical aspect for gas engineers. Gas plant systems are configured to tackle dehydration processes to meet sales gas specifications. The simulation of the natural gas diethylene glycol dehydration system was performed using HYSYS software. The natural gas composition and operation conditions were obtained directly from the gas plant. The results showed that diethylene glycol dehydration can effectively remove a certain percentage of water. Considering the economic aspect of running the plant, it can be concluded that diethylene glycol is preferable for low-temperature natural gas stream water removal operations. The results indicated that the pipeline's water content specification was met with a minimum of 2.5m3/h of DEG used to reduce the water percentage of 8MMSCFD to 5.7lb/MMSCFD, which is still within the pipeline's 6-7lb/MMSCFD limit. It is recommended that diethylene glycol should be incorporated as part of the dehydration chemicals to ensure an adequate water removal process and eliminate the risk of hydrate formation, safeguarding the process plant equipment.

Declarations
Ethics approval and consent to participate
Not applicable
Competing interest
The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
Authors contributions
N. H. A- Conceptualization, methodology, acquisition of data, funding acquisition, experimental work, supervision, drafting of article and final approval.
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