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NATURAL GAS DEHYDRATION BY USING TEG (Triethylene glycol)

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Abstract:-
The exploration and production of natural gas are usually contains large amount of water vapor during production operation. In order to protect the gas system from hydrate formation and to meet sale gas specifications it is necessary to remove water vapor from the natural gas stream; a process called dehydration. Glycol dehydration is the most frequent and cost-effective method of removing water from natural gas streams, which employs triethylene glycol (TEG) as the dehydrating agent.
The primary goal of this study is to performing a sensitivity analysis over the obtained results from the simulation and to study the possibility of optimizing the process to predict the optimum parameters in natural gas dehydration system. Three different TEG flow rates, stripping gas flow rate and reboiler temperature were used for the simulation.
Result shows that, the simulation process succeeds in reducing the water content to 0.623lb/MMSCF from an initial value of 13.80lb/MMSCF and found out the most effective parameter to remove the water vapor and estimating the TEG purity for 3750kg/h of TEG flow rate at reboiler temperature 204℃ with 1900kg/h stripping gas flow rate. Finally it appears that, using stripping gas is a more effective technique to improve the TEG purity and the overall performance of the dehydration plant.

NATURAL GAS:-

Composition of natural gas:-

The properties of natural gas depend on gas-specific gravity, pseudo-critical pressure and temperature, viscosity, gas density, compressibility factor and gas compressibility. Hence, in designing and investigating natural gas production and processing systems which requires the knowledge on these property values. The amount of water that is present in the natural gas basically depends on the composition of the natural gas also.

Nevertheless, natural gas stream is a complex mixture of hydrocarbon gases contains 70-90% methane ($CH4$) in most cases. The remaining hydrocarbons have a higher molecular weight, such as ethane ($C2H6$), propane ($C3H8$), butane ($C4H10$). There may also be water vapor, hydro sulphide, carbon dioxide ($CO2$), nitrogen ($N2$), and helium (He). In Table 1 represented the chemical composition of raw natural gas.

Table 1. Chemical composition of raw natural gas (Suckling et al., 2009).

Compound	Symbol	Wt. % in natural gas
Methane	$CH4$	60-90
Ethane	$C2H4$	0-20
Propane	$C3H8$	0-20
Butane	$C4H10$	0-20
Carbon Dioxide	$CO2$	0-8
Oxygen	$O2$	0-0.2
Nitrogen	$N2$	0-5
Hydrogen Sulfide	$H2S$	0-5
Noble gases	Ar, He, Ne, Xe	0-2

NATURAL GAS PROCESSING

Natural gas that contained at the wellhead of the reservoir, is termed as "wet gas" when other hydrocarbons are present (Anyadiegwu et al., 2014). The "wet gas" obtained from producing wells based on the type, depth, and location of the underground deposit, as well as the geology of the field. However, natural gas is contemplated as "dry" gas when it is almost pure methane ($CH4$) and having had most of the other commonly associated hydrocarbons removed. The gas processing applied to raw natural gas to achieve pipeline-quality dry natural gas is a complicated process that typically entails several steps.

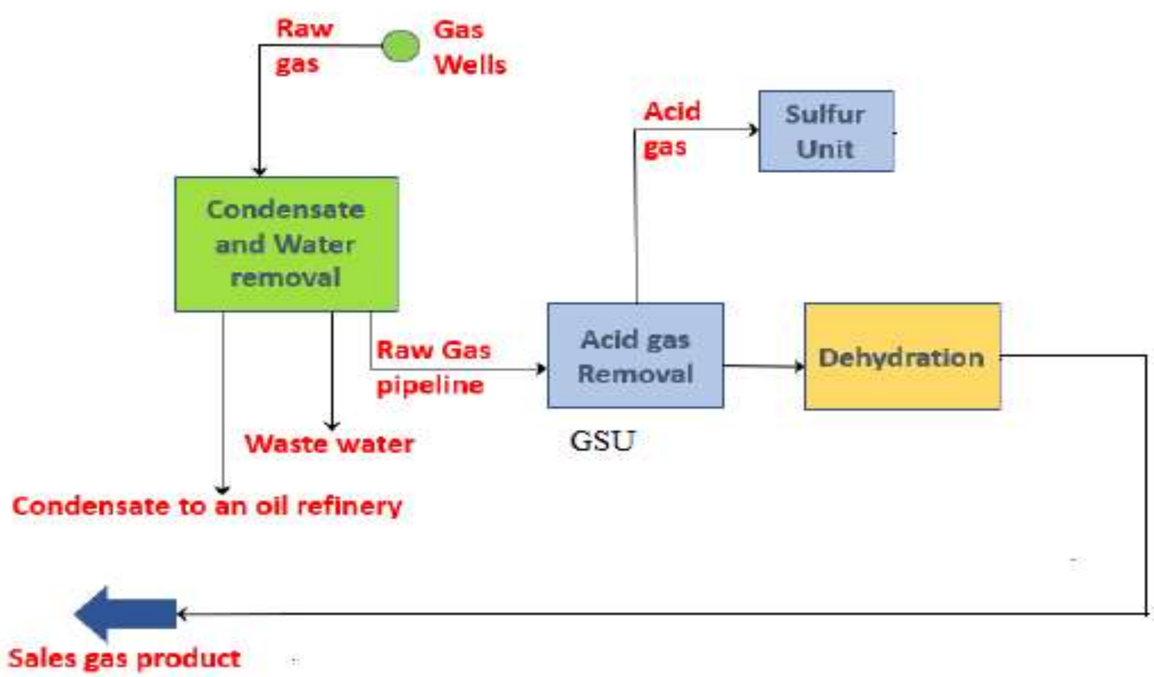


Figure 2. A typical onshore natural gas processing plant (Okafor & Evwierhurhoma, 2020)

GAS SWEETENING UNIT:-

The main function of Gas sweetening Unit or GSU is to remove Hydrogen Sulphide (H2S) and Carbon Dioxide (CO2) from the gas to meet sales gas specification. This is an absorption-regeneration type process based on MDEA (Methyl Di-ethanol Amine) as the solvent. Acid gas and Flash gas from GSU will be sent to SRU

SULPHUR RECOVERY UNIT :

Sulphur Recovery Unit (SRU) is installed to remove hydrogen sulphide from acid gas. Its operation is based on CATSOL Process

DEHYDRATION:

The removal of water from sweet gas is made by contacting the gas with Triethylene Glycol solution.

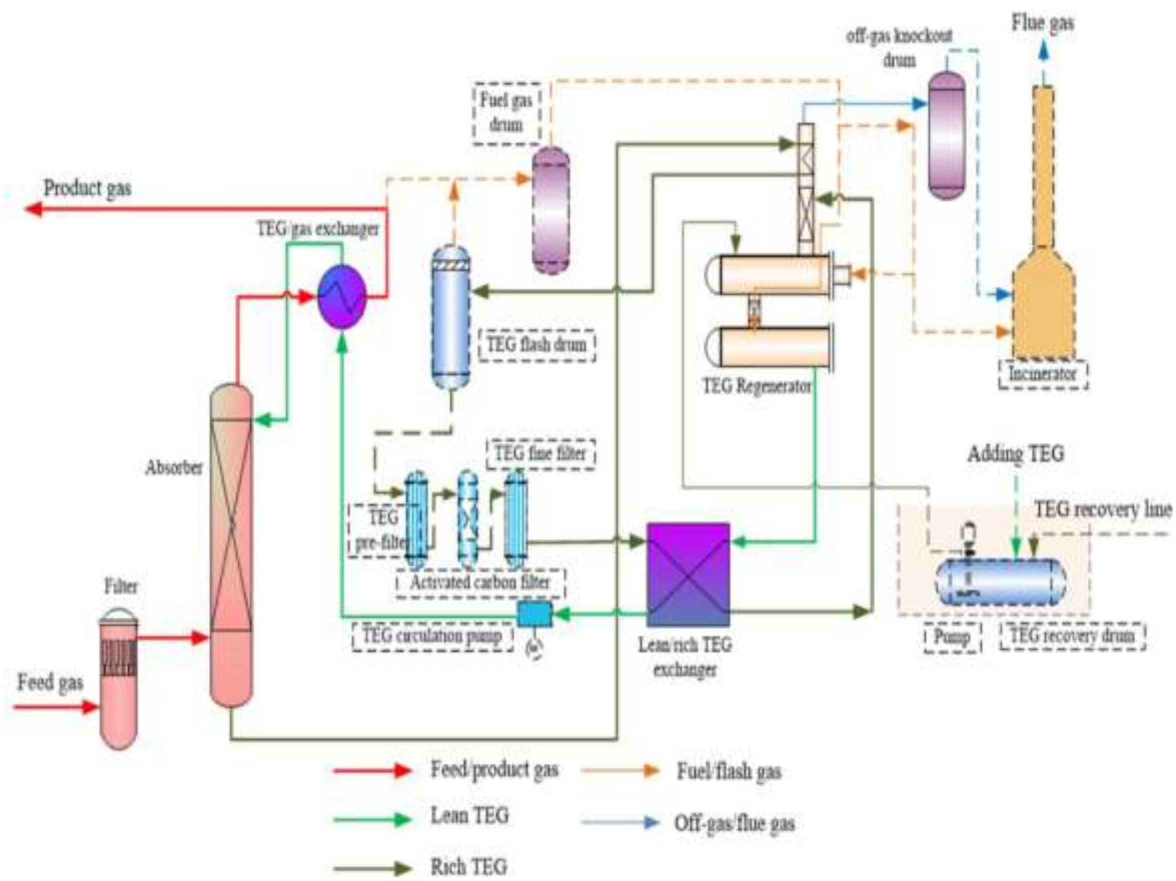


Figure 1. Traditional TEG dehydration process flow diagram.

DEHYDRATION UNIT OPERATION OBJECTIVES:

The operation of TEG dehydration system is fairly straightforward. The principals involved are well understood and the equipment used is fairly simple. When things are running as they as they should, the unit may seem to operate by itself. This is not to say that things never go wrong, however, and a lesson soon learned is that the best insurance against operation problem is a team of knowledgeable and observant operators.

Perhaps the biggest potential is that TEG system can get dirty (and corrosive) quickly; when TEG system are not well kept, large amount of hydrocarbon and solids can produce several types of different but related problem. Sometime operators don't understand the system as well as they should and begin to follow particles (such as keeping regeneration temperatures too high) that actually degrade system performance. Sometimes even the simplest equipment can fill and produce symptoms that are hard to figure out, especially if operator don't know their system as well as they should.

Regardless of the cause, problem in TEG system usually manifest themselves in the following ways:

1. The water content of the "dehydrated" gas increases and the dew point specification cannot be maintained. This in turn causes more problem in downstream units.
2. Adequate lean TEG strength cannot be maintained.
3. TEG foaming and carryover problem caused by solution contamination appear and further degrade system performance and operability.
4. Improper operation or system upsets cause, TEG to be lost from the system, new TEG must be added from storage more frequently and chemical usage cost increase.
5. Corrosion gets out of control. Corrosion by-products cause continual upsets and the system "eats itself alive".

Once operator are aware of the kinds of things that can go wrong and are able to understand their cause, problems should be fewer and farther between. Simply knowing and understanding these things is not enough, however. TEG system must constantly be monitored and maintained: filters must be checked, or replaced when necessary; TEG quality must be regularly tested for several critical properties; hydrocarbon skimmer levels, regenerator temperatures and other operating parameters must be checked and adjusted if necessary;

With such though as these in mind, we can now list the operational objectives forTEG dehydration units:

1. Maintain dry gas dew point specification at all times.

This is accomplished by:

- Maintaining adequate lean TEG strength.
- Maintaining adequate lean TEG circulation rates.

2. Maintain efficient TEG regeneration.

This is accomplished by:

- Keeping the TEG clean.
- Testing the TEG often.
- Preventing TEG losses.

ABSORPTION SECTION:-

Sweet gas from Gas Sweetening Unit (GSU) enters the dehydration unit and is routed to feed gas KOD with flow control value. The entrained or condensed liquids are removed in Feed Gas KOD. The entrained or condensed liquids from KOD are routed to Amine Blow down Header under level control. The gas is then fed to Glycol Absorber where it is contacted with lean tri-ethylene glycol solution (99.7 %Wt).

This column is provided with packed bed where gas flows upward through bed of the glycol contactor for counter current contact with Tri-ethylene Glycol. Glycol absorber column is provided with demister pad to prevent the carryover of glycol along with the gas. Dehydrated gas exits from the top of Glycol contactor is scrubbed for any glycol carryover in the Glycol filter separator and then sent to downstream hydrocarbon dew point depression units (DPDU).

Rich Glycol is drawn-off under level control off the bottom from the absorber and Glycol Filter Separator and is routed to the regeneration section.

Regeneration Section:-

Rich Glycol received from Absorption Section enters Degassing Drum where the absorbed light hydrocarbons are released and sent under pressure control to fuel gas network. Degassing drum is equipped with Heavy Hydrocarbon skimming lines. The Degassed Glycol leaving from Degassing drum and enters the Glycol Filtration Package consisting of Cartridge Filters followed by Charcoal Filter followed by Another Cartridge Filters provided at downstream of Charcoal Filters.

Before entering the still column to be regenerated, glycol is preheated in two steps. Firstly, in a heating coil at top of the regeneration column, providing the desired overhead reflux which is controlled by the 3 ways overhead temperature control valve and secondly in the Glycol/Glycol Exchangers (Plate Heat Exchanger Type), by the regenerated glycol.

The glycol regeneration column fitted with 5 trays is top mounted on the re-boiler. The bath temperature is controlled at 204^{o} C by the action on the steam flow rate to the re- boiler.

Lean TEG leaving from re-boiler is afterwards stripped by dry fuel gas in the packed stripping column to reach the final concentration of 99.7 % Wt. Then, it returns to the glycol surge drum, after being cooled to 116.3^{o} C in the Glycol / Glycol exchanger.

From the surge drum, it is pumped by the reciprocating pumps to the Lean Glycol cooler for cooling the lean glycol to 36.4^{o} C and further sent back to the absorber.

LEAN GLYCOL STORAGE SECTION:-

Initial fresh Glycol is filled into Lean Glycol tank either by Road tankers or Drums using Glycol Loading Pump.

During normal operation, fuel gas from outsource will takes and then passed through the re-boiler hot bath before being injected at bottom of the stripping column. During start-up, Dry fuel gas/Nitrogen needed for the glycol stripping is available from the treated gas leaving the dried gas filter separator, which is relieved and then passed through the re-boiler hot bath before being injected at bottom of the stripping column.

A lean glycol storage tank and its attached pump allow glycol transfer and make- up. A glycol sump drum is provided for collecting TEG drips and drains from various sources throughout the unit. The solution is returned to the lean glycol tank via the sump pump. This pump starts automatically in case of high level in the glycol sump drum.

TEG PROPERTIES:-

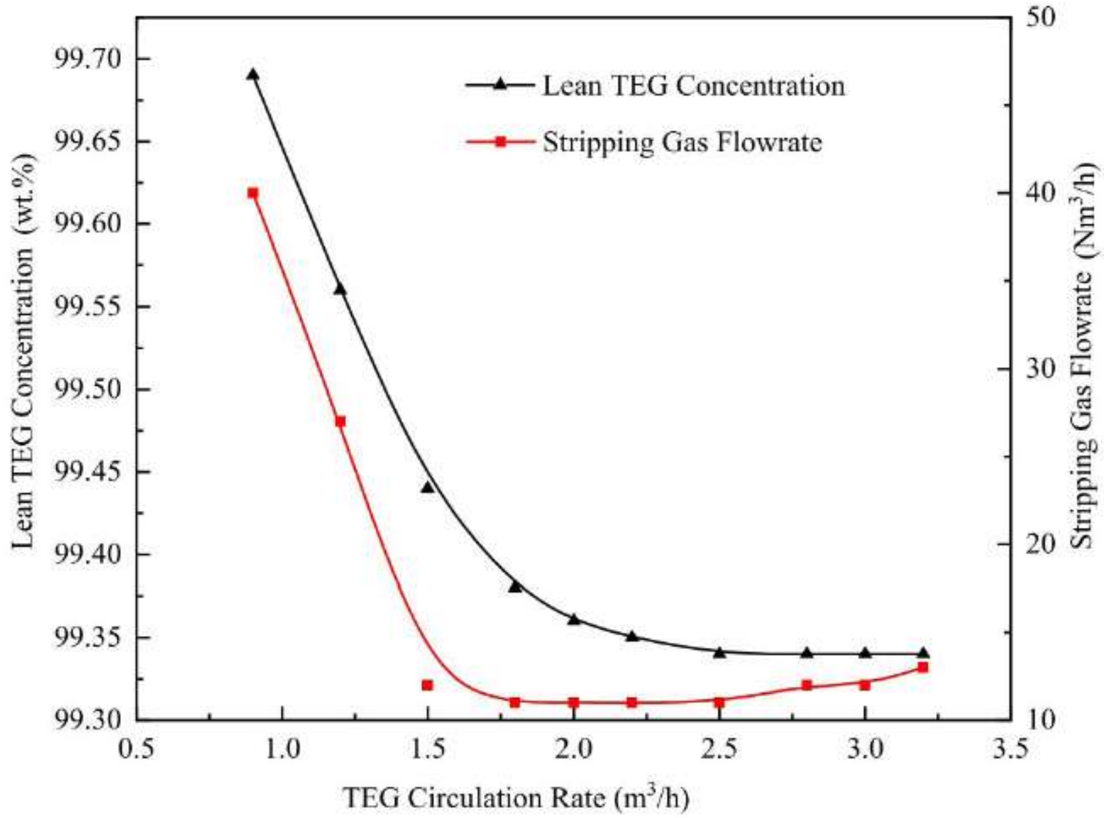
A good liquid desiccant should be:

- be highly hygroscopic
- be noncorrosive
- be easily regenerated to a high concentration
- be separated easily
- be essentially non soluble in liquid hydrocarbons

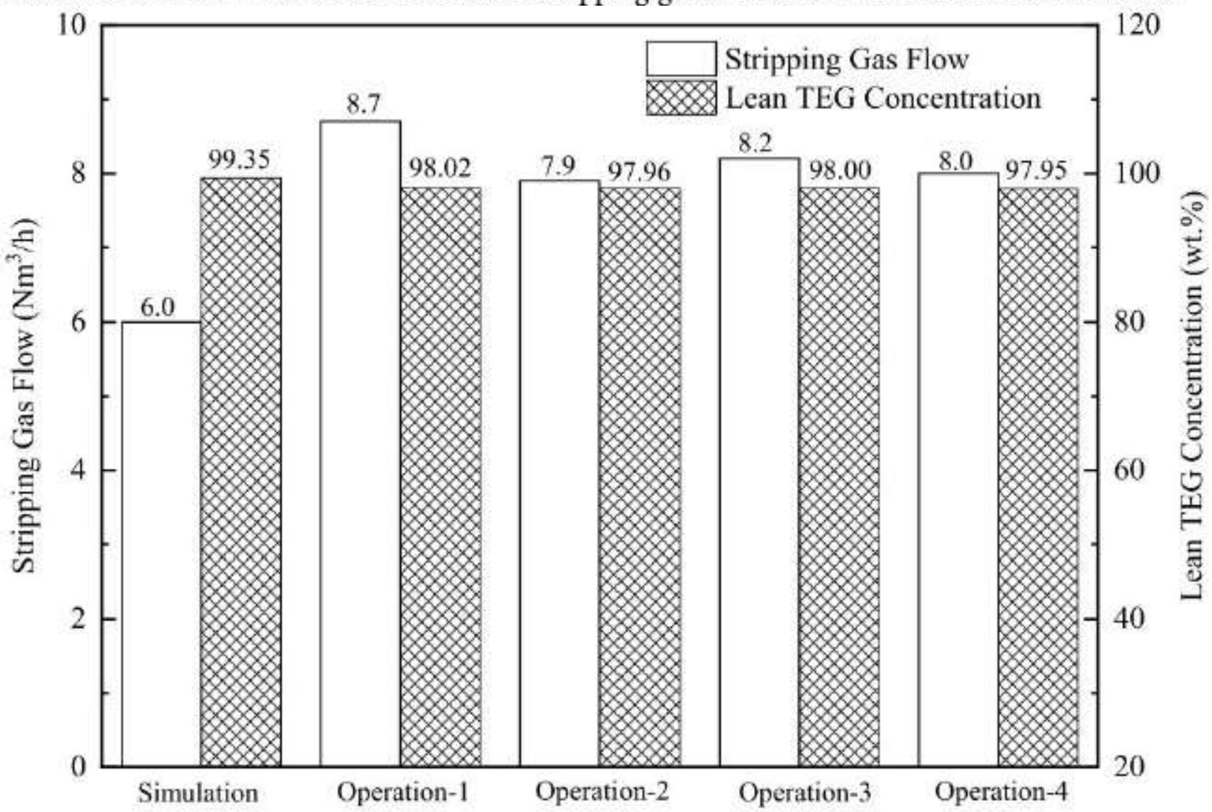
A good liquid desiccant should not:

- be highly viscous
- solidify in concentrated solution
- form precipitates with gas stream components
- be difficult to handle
- be a threat to the environment

- **PHYSICAL AND CHEMICAL PROPERTIES:-**
- Molecular Weight: 150.20
- Chemical Formula: $C_6H_{14}O_4$
- Appearance: Clear, colorless liquid.
- Odour: Odourless
- .Solubility: Miscible in water.
- Specific Gravity: 1.1274 @ 15C/4C
- pH: 5.5-7.5
- % Volatiles by volume @ 21C (70F): 100
- Boiling Point: 285C (545F)
- Melting Point: -5C (23F)
- Vapour Density (Air=1): 5.17
- Vapour Pressure (mm Hg):< 0.01 @ 20C (68F)
- Evaporation Rate (BuAc=1): 0.01



Variation of the lean TEG concentration and stripping gas at different TEG circulation flowrates.



Comparison of the stripping gas flow and lean TEG concentration.

CONCLUSION:-

The process simulated a steady-state simulation of the TEG dehydration unit in a domestic natural gas processing plant. Process evaluation was performed to minimize the TAC of the base case by adding stripping gas to the TEG Regenerator by rerouting vapor from TEG Flash Drum, instead of venting/flaring it.

The final results show that by adding the stripping gas from the vapor of TEG Flash Drum, the TEG circulation mass flow rate can be reduced while satisfying the water moisture in the dry gas specification.

Therefore, the reboiler duty is reduced from 1.464 to 0.934 GJ/h (a 36.2% reduction), the concentration of water moisture in dry gas is slightly reduced from 13.62 to 0.623 lb/MMSCF and the TAC is reduced from $296 058/year to $236 890/year (20.0% reduction). Therefore, a more economical design of a natural gas dehydration unit using TEG than the base case design was obtained

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