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Optimization Of Natural Gas Dehydration Using Triethylene Glycol (Teg)

R.O Felicia
Department of Chemical Engineering
Faculty of Engineering, University of Port Harcourt.
Port Harcourt, Nigeria.
engr_ruky@yahoo.com

B.O Evbuomwan
Department of Chemical Engineering
Faculty of Engineering, University of Port Harcourt,
Port Harcourt, Nigeria.
b_evbuomwan@yahoo.com

***Abstract*—Natural gas from reservoirs usually contains water vapor, the presence of this vapor causes flow assurance issues hence the need to dehydrate the gas and optimize the process. Optimization of natural gas dehydration using Tri-ethylene glycol was carried out using Aspen HYSYS process software and regression analysis. With all units optimally specified during the process, the lean TEG inflow rate was varied with the water content in the dry gas product stream of the contactor column. The generated data from HYSYS is modeled using a regression approach. Linear and Quadratic models were generated and the best model with high R square value was selected. Optimization of the TEG dehydration process using the selected model was achieved through application of relative extrema techniques in differential calculus. From the result it was deduced that the optimum flow-rate of glycol needed for dehydration is 23932lb/day and the corresponding rate of water is 88.3785lb/day. Thus water composition before the simulation 0.004 was reduced to 0.00007 by mole at the end of the process.**

Keywords—TEG, dehydration, naturalgas, optimization.

I. INTRODUCTION

Natural gas is a fossil fuel formed from the remains of buried plants, gases, and animals that are exposed to intense heat and pressure over thousands of years. It is an energy source often used for heating, cooking, electricity generation and fuel for vehicles. [1] The global demand for energy has spurred the search for alternative sources of primary energy. Moreover, natural gas remains the third most widely used energy source in the world, ranking just below coal.[2] Natural gas has less environmental impact when compared to crude oil and coal because it burns cleaner and more efficiently and with lower levels of potentially harmful byproducts that are released into the atmosphere. [3]

It occur as hydrocarbon and non-hydrocarbon gas mixtures which occur naturally in underground rock reservoirs found in gas fields sited onshore and offshore. It could exist as a free gas referred to as non-associated gas or in association with crude oil which is then referred to as associated gas. Natural gas from oil wells is comprised of hydrocarbons such as methane, ethane, propane, and butane. [4] Along with other heavier hydrocarbons it also contains impurities which can have harmful effects like corrosion of pipes and hydrate formation during processing. [5] [6]. Corrosion occurs when the pipeline is exposed to water and other contaminants such as O_2, H_2S, CO_2, and chlorides. There are different methods for dehydrating natural gas, but the two principal processes are adsorption and absorption. [7]Absorption is the use of liquid desiccant to remove water content in a counter current contact from the gas stream. Water and glycols show complete mutual solubility in the liquid phase due to hydrogen-oxygen bonds and their water vapor pressures are very low. Glycols are the most commonly used liquid desiccants in the absorption process, they are; mono-ethylene glycol (MEG), di-ethylene glycol (DEG), tri-ethylene glycol (TEG) and tetra-ethylene glycol (TREG).[7] TEG is the most commonly used glycol for natural gas dehydration; this is because it can be regenerated to high concentration without degradation.[8]

II. MATERIALS AND METHOD

This paper seeks to optimize natural gas dehydration using TEG, Aspen HYSYS was used in simulating the gas dehydration process, it is an easy-use process modeling environment which enables optimization of processes and operations, it has a broad array of features and functionalities that addresses engineering process. HYSYS can handle multiphase flow modeling, gas processing and refinery reactors making it the best choice for modeling and optimization hydrocarbon processes from wellhead to sales point.

TABLE I. NATURAL GAS COMPOSITION AND CONDITION

Components	Mole %
Methane	0.574
Ethane	0.12
Propane	0.174
i-Butane	0.038
n-Butane	0.064
i-Pentane	0.01
n-Pentane	0.007
Pseudo-C6	0.003
Pseudo-C7	0.001
Pseudo-C8	0
Pseudo-C9	0
Nitrogen	0.002
Carbon (IV) Oxide	0.003
Hydrogen Sulfide	0
Oxygen	0
Water	0.004
Operating Conditions	
Pressure	93bar
Temperature	43.111 C
Flow rate	2000kgmole/hr.

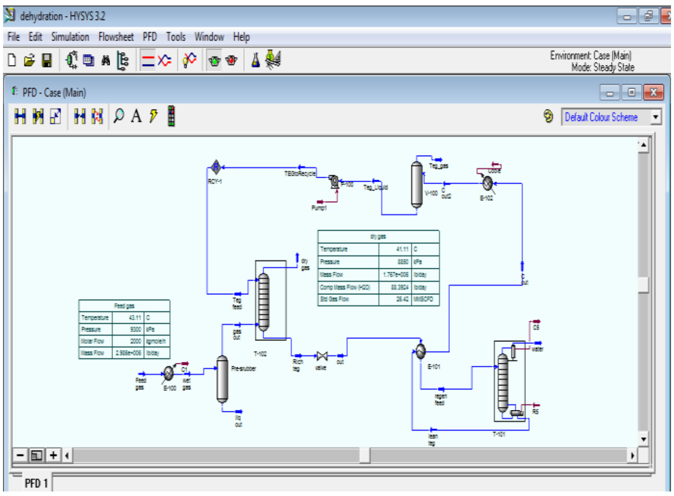

Fig 1.Complete process flow diagram of gas dehydration

Fig. 1 shows the PFD of the dehydration process, here, Natural gas from reservoir is cooled and then comes out as wet gas and this is due to the fact that at low temperature dehydration is more efficient. Liquid droplets in the wet gas are removed as it passes through the pre-scrubber before going into the absorber.

A. Absorber (Contactor Column)

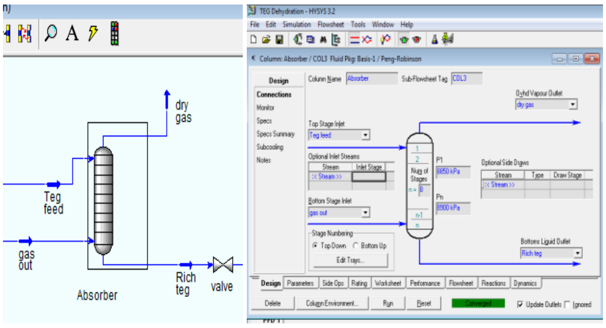

Fig. 2 Absorber design and specification

In the absorber, gas goes in through the bottom while lean glycol enters the contactor from the top. The lean glycol flows in counter-current to the rising wet gas, absorbing water from the gas and leaves the bottom of the absorber as rich glycol (glycol with water content) and the gas goes out as dry gas.

The counter flow in the contactor makes it possible for the gas to transfer a high amount of water to the glycol, and thus the efficiency of the dehydration is measured by the water content in the dry gas that exit from the top of the absorber.

The rich (wet) glycol leaves the bottom of the absorber, flows through a pressure control valve, and then through a heat exchanger where the temperature is raised before it enters the regenerator through a top stage.

B. Regenerator

Here, water is separated (stripped out) from the glycol. The rich glycol enters the stripper after it has been heated by the heat exchanger. The liquid gets hotter and hotter as it falls and water vapor flashes out of the liquid, the glycols settle at the bottom and recycled back into the absorber, water vapors exits from the top of the column.

III. RESULTS AND DISCUSSION

A. HYSYS Simulation Results

With the complete TEG dehydration Process Flow Diagram (PFD) solved, the Lean TEG (kg/h) was varied with the water content (kg/h) of the dehydration ‘dry gas’ product. The initial approach was to increase the TEG rate from 10,000lb/d through 50000lb/day, the corresponding water in downstream gas rate were recorded and a plot using excel spreadsheet showed that the optimal value for TEG rate was between 23550lb/day and 24500lb/day.

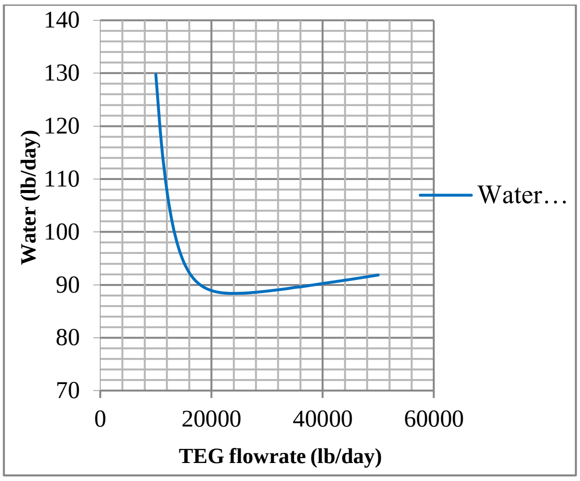

Fig. 3 Water in Dry gas versus Lean TEG

Fig 3 shows the plot between Lean TEG and water in the dry gas but for a clearer analysis and better result, values of TEG rate between 23550lb/day and 24500lb/day was varied, this was because the curve for water versus TEG appeared to have turned in that interval. The water rates were measured for every 50lb/day increase in TEG rate in this interval of interest. The plot reveals that the optimal glycol rate is in this interval. The primary task in this work is to find the optimal glycol rate.

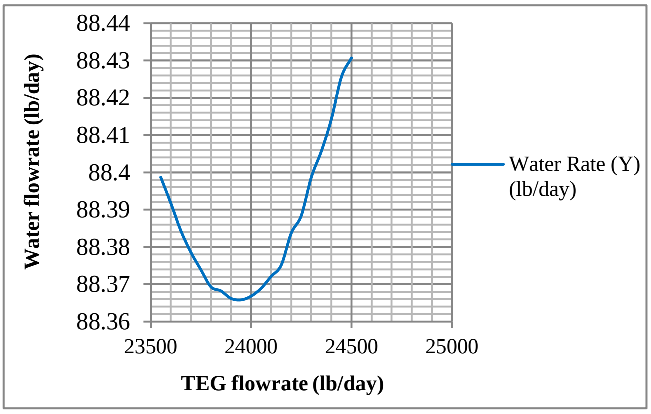

Fig. 4 Water in Dry Gas versus Lean TEG

B. Regression Analysis

The generated data from HYSYS is modeled using regression approach. Linear and Quadratic models were generated using Microsoft Excel Spreadsheet application.

1) Linear Model

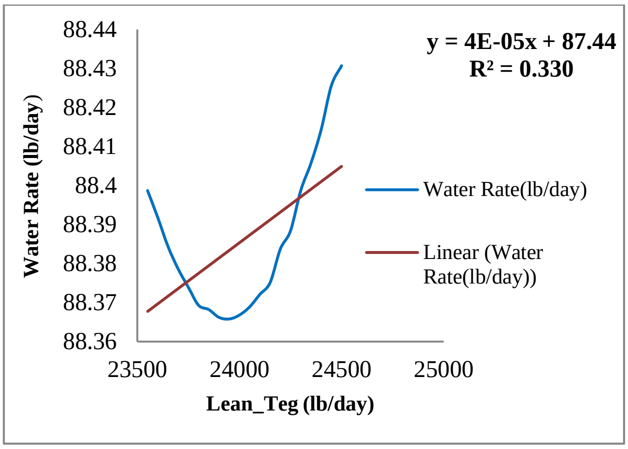

Fig. 5 HYSYS versus Model (Linear)

Fig. 5, the Linear Model shows a poor correlation (R= 0.331) between values generated from this model and those generated from HYSYS. The coefficient of determination (R^2) is the measure of how well the regression equation (line) truly represent or fits your set of data [9].

2) Quadratic Model

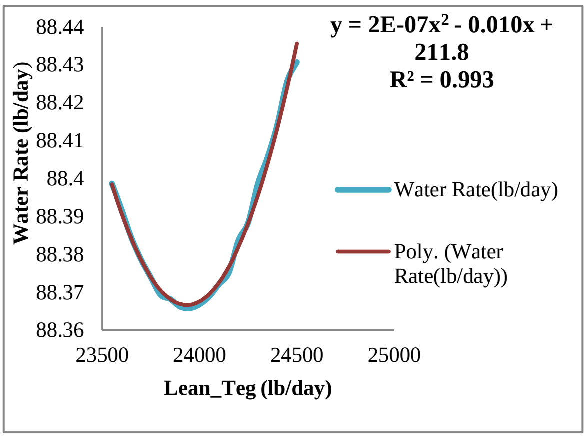

Fig. 6 HYSYS versus Model (Quadratic)

The plot (Figure 6) of the HYSYS and quadratic model shows an excellent correlation between values generated from this model and those generated from HYSYS with R square value of 0.993 and a supporting visual consistency.

Hence, the quadratic model is;

$$y = 211.802002 - 0.010314557x + 0.0000002155x^2$$

Where Y is the water mass flow rate (lb/day) in downstream gas; and X is the Lean TEG mass inflow rate (lb/day). The model is quadratic and differential calculus was used to find a value of X at which Y would be minimal.

C. TEG DEHYDRATION OPTIMIZATION USING SELECTED MODEL

Applying differential calculus, the optimal value for the lean TEG can be found. The selected model is a quadratic equation with a minimum point, (X_{min}, Ymin). Y_{min} represent the minimum water rate while the X_{min} represent the optimum glycol rate.

Starting from the model,

$y = 211.802002 - 0.010314557x + 0.0000002155x^2$

The first derivative of Y with respect to X is solved as follows

$$\frac{dy}{dx} = -0.010314557 + 0.000000431\,x$$

At the turning point (minimum point), $\frac{dy}{dx} = 0$

This implies that,

$-0.010314557 + 0.000000431\,x = 0$

$\boldsymbol{x} = \frac{0.010314557}{0.000000431} = 23932$lb/day

Therefore,

$\mathbf{X}_{min}$ = 23932 lb/day and

$\mathbf{Y}_{min}$ = 88.3785lb/day

From the result it can be deduced that the optimum flow-rate of glycol needed for dehydration is 23932lb/day and the corresponding rate of water is 88.3785lb/day. The initial composition of water in the natural gas stream before the simulation was 0.004 by mole and at the end of the process simulation the composition of water was reduced to 0.00007 by mole.

From the result it can be deduced that the optimum flowrate of glycol needed for dehydration is 23932lb/day and the corresponding rate of water is 88.3785lb/day. The initial composition of water in the natural gas stream before the simulation was 0.004 by mole and at the end of the process simulation the composition of water was reduced to 0.00007 by mole.

IV. CONCLUSION

In conclusion, the presence of water in natural gas causes flow assurance issue hence the need to dehydrated the gas. With the use of HYSYS software, the gas was dehydrated and process optimized. Results obtained shows a decrease then an increase in water rate as lean TEG rate increases, regression analysis was carried out on the set of data obtained and models were generated, Quadratic Model was selected because the model correlated with the set of data from HYSYS (R^2=0.993). Using the selected model (quadratic model), differential calculus was applied in determining the optimal TEG rate which gave 23932lb/day.

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