SIMULATION OF GAS DEHYDRATION USING TRIETHYLENE GLYCOL (A CASE STUDY OF A NIGER/DELTA FIELD, NIGERIA)

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ABSTRACT-*The formation of hydrates in gas lines and/or processing equipment is very dangerous in most cases as it can lead to the reduction of pressure across lines/equipment as well as possible line blockage. This study demonstrates an Aspen Hysys (glycol package model approach) aided simulation of gas dehydration using Tri-ethylene Glycol (TEG) as the dehydrating agent thereby considering two (2) different cases of changing the flow rate of TEG and observing the corresponding effects on the rate of water removal from the natural gas, the ratio of TEG flow rate to effluent dry Gas flow rate, as well as the effect of increasing TEG temperature on quantity of water content in the effluent gas stream. From the three (3) main scenarios examined, sensitivity analysis of the simulation results shows that: increased TEG flow rate favors the removal of water from the natural gas. However, increased in TEG flow rate does not lead to an increase in the proportion of water removed from the wet gas, thus giving the optimum TEG flow rate for (this particular plant) natural gas drying as 420kgmole/hr, and also, the increase in TEG temperature leads to an increase in the water content of the dehydrated gas, at a constant wet gas temperature. Tabular representations and graphical analysis of results were displayed to further drive home the outcome of the simulation. Adopting the technique used in this study, hydrate formation can be adequately managed in other processing facilities.*

Keywords: Formation of hydrates, gas lines, Aspen Hysys, Gas Dehydration, Dehydrating Agent, Flow rate, Simulation

1.0 INTRODUCTION

The production and transportation of oil and gas fluids in remote locations as well as under severe climate conditions can present major technical challenges to operators (Borere, 2008). This is because of the inherent characteristics of produced fluids, which can lead to operational issues such as corrosion, hydrate occurrence, scaling, wax and/or paraffin deposition (Menendez et al., 2014). Changes due to properties of produced fluids over the life cycle of an asset can also introduce operational implications. Consequently, a thorough consideration of these various issues is necessary in order to maintain flow assurance and assets integrity during the lifetime of a producing field.

The transportation of unprocessed fluids from offshore to onshore processing facilities is an attractive economic incentive since significant capital savings can be achieved. This kind of operational practice can bring along the potential risks of corrosion and hydrate formation in wet gas transportation systems (Mok et al., 2007). The main cause of these problems is the presence of water, and dissolved in it acid gases like carbon dioxide (CO_2) and/or hydrogen sulphide (H_2S) which generates highly corrosive environments. The presence of water can also present a risk of hydrate formation under certain operating conditions which can be influenced by seasonal variations.

Hydrates have long been the biggest problem in flow assurance for the petroleum industry (Macintosh, 2000). And as new resources are often smaller and located in areas with more extreme conditions, hydrates remain a major obstacle for the further supply of hydrocarbons.

Hydrates can quickly build up and block a pipeline even at operating temperatures of up to 30^{o}C (Lovell et al., 2002). Once a line is blocked there is no telling on how long it will take to clear the hydrate plugs; this operation can take days or even a month. Remedial operations can involve safety concerns because of potential risks of sudden gas expansion.

A viable preventive measure from the aforementioned problems associated with natural gas transportation is the application of gas dehydration technique prior to transporting. This brings the need to embark on this study, to run a simulation of gas dehydration technique capable of preventing the aforementioned problems since the source of hydrate formation/corrosion being water would have already been eliminated or reduced to negligible amount prior to transportation/sales. The aim of this work is to simulate an operating natural gas dehydration plant (Niger/Delta, Nigeria) to expunge/drastically reduce the gas water content to prevent flow assurance concerns such as hydrate formation, slugging, corrosion, etc. using Aspen Hysys simulation package, with the following objectives:

- To perform an Aspen Hysys simulation of gas dehydration.
- To determine the impact of Triethylene Glycol (TEG) treatment on natural gas properties using "Glycol Package" as the Fluid Package in the Simulation Basis Manager.
- To see the effects of TEG on natural gas Water Content, Wobbe Index, and Heating Value.

2.0 RESEARCH METHODOLOGY

2.1 Data Presentation

The under-listed plant field data is will serve as an input to the proposed simulation:

Table 1: Gas Plant Field Data

Components	Mole %
Nitrogen	0.0016
H_2S	0.0172
CO_2	0.0413
Methane	0.8692
Ethane	0.0393
Propane	0.0093
i-Butane	0.0026
n-Butane	0.0029
i-Pentane	0.0014
n-Pentane	0.0012
n-Hexane	0.0018
H2O	0.0122

Table 2: Gas Plant Operating Conditions

Operating Conditions	
Temperature	25ºC
Pressure	506.6 kPa
Molar Flow	1250 Kgmole/h

Aspen hysys tool was selected for this study simulation due to its global acceptability and effectiveness in performing oil and gas simulations. Simulation of the dehydration system was modeled for possible effects of key input parameters on the rate of water removal from the TEG contactor. The following cases are considered during the course of the project simulation. TEG Flow rates were varied and corresponding results were generated after each simulation.

- **Effects of TEG flow rate on water removal:** In this case scenario, TEG flowrate was varied from 420kgmole/h to 500kgmole/h, at constant TEG temperature, constant TEG pressure and the operating condition of the Gas plant to see how it affects the rate of water removed from the wet gas. From the same tweaking, the effects on Wobbe index and Heating value were determined.

Table 3: Case 1 (Simulation Results obtained from Demonstrating the Effects of TEG Flow Rate on Water Removal from the Wet Gas Stream)

S/N	TEG Flow Rate (Kgmole/h)	Gas Out Water Content (mg/Nm^3)	Liquid Out Water Concentration (%)	Wobbe Index (MJ/m^3)	Higher Heating Value (Kj/kgmole)	Lower Heating Value (Kj/kgmole)
1	420	7.424×10^{-14}	0.0346	47.84	9.030×10^5	8.214×10^5
2	440	4.689×10^{-14}	0.0331	47.84	9.030×10^5	8.213×10^5
3	460	3.022×10^{-14}	0.0317	47.84	9.030×10^5	8.213×10^5
4	480	1.983×10^{-14}	0.0304	47.85	9.029×10^5	8.213×10^5
5	500	1.324×10^{-14}	0.0292	47.85	9.029×10^5	8.212×10^5

- **Ratio of TEG flow rate to the Dry Gas flow rate:** In this case scenario, TEG flowrate was also varied from 100kgmole/h to 500kgmole/h to see how the TEG flowrate affects the Dry Gas flowrate

Table 4: Case 2 (Simulation Results obtained from Demonstrating the Ratio of Dry Gas Flow Rate to TEG Flow Rate)

S/N	TEG Flow Rate(Kgmole/h)	Gas Flow Rate (Kgmole/h)
1	100	1234
2	200	1232
3	300	1231
4	400	1230
5	500	1228

- **Effects of increased TEG Temperature on the water content of the dehydrated gas**: For this case scenario, TEG temperature is varied from 25 ºC to 125 ºC to see how increase in TEG temperature relates with the water content of the dehydrated g**as.**

Table 5: Case 3 (Simulation Results gotten from Demonstrating the Effects of Increased TEG)

S/N	TEG Temperature (ºC)	Water Content of Dehydrated Gas (mg/Nm^3)
1	25	1.1E-10
2	50	0.000027
3	75	0.3166
4	100	61.09
5	125	448.4

2.2 Methods

The dehydration plant is simulated by using Aspen HYSYS. The TEG is utilized as an aqueous absorbent to absorb water vapour from wet gas stream. The first step of simulation is done by adding the gas stream compositions and conditions by utilizing the afore-stated data of this case study. It is important to carefully choose the Hysys fluid package to use for the simulation, which should be (Glycol Package) as shown in Appendix A, figure A1.

After going past the above step, the simulation environment will be entered. However, the simulation tab in Aspen Hysys is considered the main working area, which deals with the system(s) being simulated. It's important to define various material

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streams such as under consideration (Gas Plant wet gas stream composition and conditions, wet gas properties generated by the simulation tool, and TEG stream for the simulation) at the beginning of simulation. After which, we defined the absorber and connect the wet gas and TEG feed streams.

Upon the definition of the material streams (TEG & wet gas), a connection is made with the Absorber/TEG contactor to properly strip off the water content and charged via the absorber liquid outlet; whereas the dehydrated gas flows through the gas outlet as shown Appendix A, figure A2 :

3.0 RESULTS AND DISCUSSION

3.1 Case 1: This case scenario demonstrates the effects of TEG flow rate on water removal from the wet gas stream.

3.1.1 TEG Flow Rate versus Percentage of Water Removed: From figure 1, it can be deduced that the increase in TEG flow rate leads to a decrease in the proportions of water removed from the wet gas. This clearly shows that the flowrate of TEG with respect to the percentage water removal from the wet gas stream are inversely proportional.

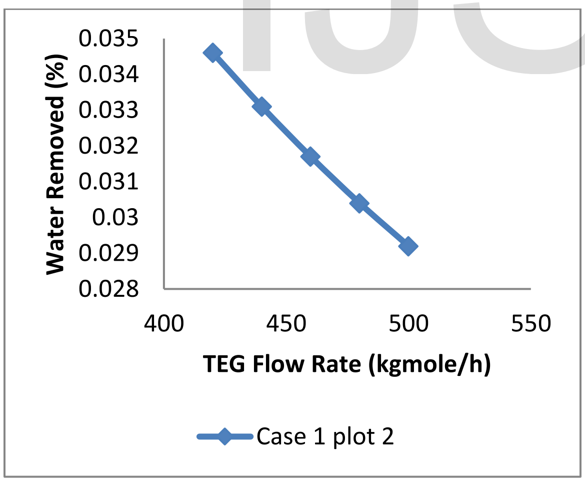

Fig.1: TEG Flow Rate versus Percentage of Water Removed

3.1.2 Flow Rate versus Water Content of Dehydrated Gas: Evidently, the plot in Figure 2 shows various water content variations of the dehydrated natural gas for each change in TEG flow rate. Consequently, it can be deduced from the graph that the higher the flow rate of TEG, the lower the water content of the gas. This shows the inverse proportionality between the flow rate of TEG and the water content of the gas being dehydrated. Also, this shows that an increased flow rate of TEG being the dehydrating agent favors the removal of water from the natural gas.

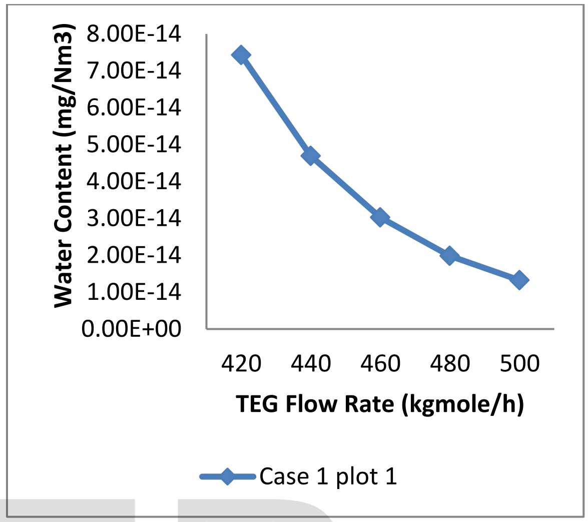

Fig. 2: TEG Flow Rate versus Water Content of Dehydrated Gas

3.1.3 TEG Flow Rate versus Wobbe Index of Dehydrated Gas: From the figure 3 showing the Wobbe Index plot, it is demonstrated that from TEG flow rates of 420 to 460kgmole/h, the wobbe index remained constant at 47.84MJ/m^3, while the wobbe index for corresponding TEG flow rate of 480 and 500kgmole.h also remained constant at 47.85MJ/m^3 although slightly higher than TEG flow rate from 420 to 460kgmole/h. The Wobbe Index, which is the interchangeability of fuel gases and their ability to deliver energy, is not too high to cause overheating or high carbon monoxide emission and it is not also too low to cause flame instability or flash-back, as the values gotten from the simulation falls in-between the standard range.

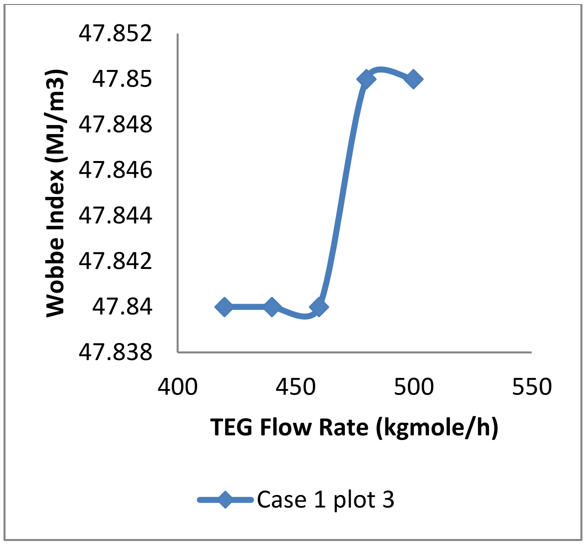

Fig. 3: TEG Flow Rate versus Wobbe Index of Dehydrated Gas

3.1.4 TEG Flow Rate versus Heating Value (Upper & Lower Limits) of Dehydrated Gas: From the gas heating value (which is the amount of heat provided by a complete combustion of a unit quantity of fuel) versus TEG flow rate plot in Figure 4, it is also deduced as clearly depicted in the plot that the flow rates of TEG under consideration for this case scenario had no significant effect on the heating value of the dehydrated natural gas.

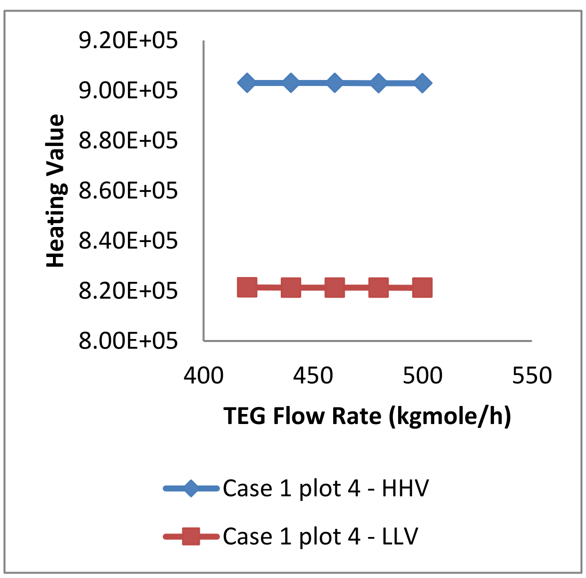

Fig. 4: TEG Flow Rate versus Heating Value (Upper & Lower Limits) of Dehydrated Gas

3.2 Case 2: This Case Scenario Demonstrates the Ratio of TEG Flow Rate to Dry Gas Flow Rate:

Figure 5 also demonstrates that the increase in TEG flow rate leads to a decrease in the gas outlet flow rate. This is symbolic of the fact that flow rate of TEG and that of the dry gas are inversely proportional. Therefore, depending on the necessity of gas flow rate at a particular production regime, the flow rate of TEG could be varied to get the desired flow rate of the dry gas.

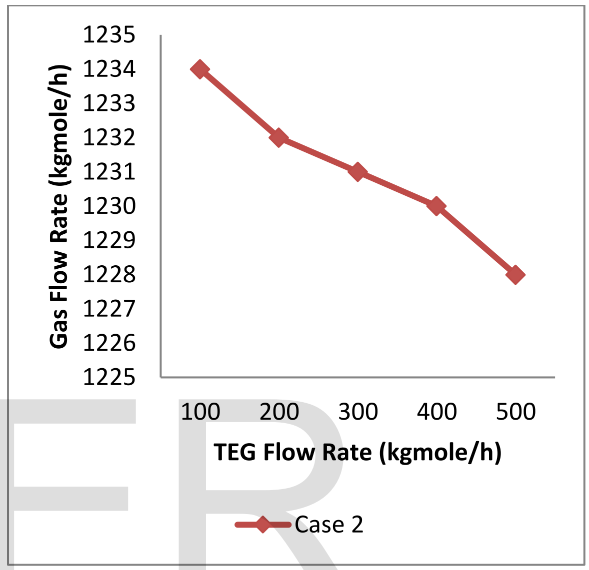

Fig. 5: TEG Flow Rate versus Gas Flow Rate

3.3 Case 3: This Case Scenario Demonstrates the Effects of Increased TEG Temperature on the Water Content of the Dehydrated Gas: According to the graphical demonstration displayed in Figure 6, it is clearly seen that unlike the previous simulation cases (cases 1 and 2), the increase in TEG temperature leads to an increase in the water content of dehydrated Gas. This trend shows that the temperature of TEG and the water content of dehydrated natural gas are indirectly proportional.

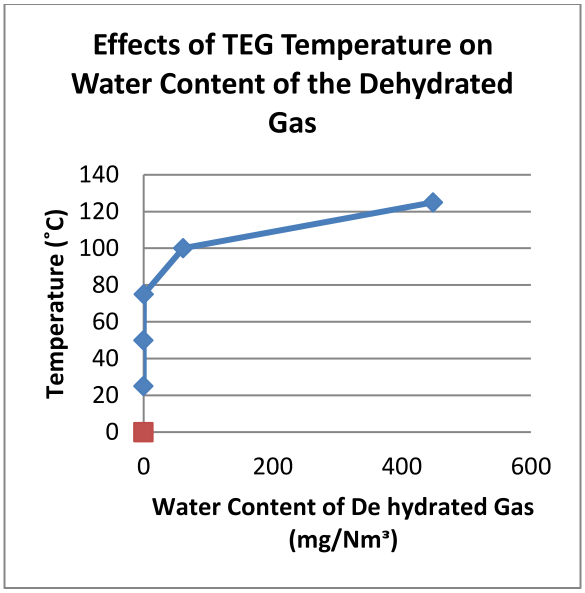

Fig. 6: TEG Temperature versus Gas Flow Rate

4.0 CONCLUSION

From the three main scenarios examined, sensitivity analysis of the simulation results shows that:

- Increased TEG flow rate favors the removal of water from the natural gas. However, an increase in TEG flow rate does not lead to an increase in the proportions of water removed from the wet gas, thus giving the optimum TEG flow rate for (this particular plant) natural gas drying as 420kgmole/h.
- The Wobbe Index is not too high to cause overheating or high carbon monoxide emission and it is not also too low to cause flame instability or flash-back, as the values gotten from the simulation falls within the standard range (ISO EN 6976:2005)..
- The heating values have no significant effect on the higher and lower heating value (HHV & LHV) of the dehydrated natural gas.
- The increase in TEG flow rate leads to a decrease in the gas outlet flow rate. Hence, depending on the necessity of gas flow rate at a particular flow regime, the flow rate of TEG could be changed to get the desired flow rate of the dry gas.
- The increase in TEG temperature leads to an increase in the water content of the dehydrated gas, at a constant wet gas temperature.
- Consequently, this study has helped in defining the heterogeneities in the effects of tweaking the flow rate of TEG on the flow rate of natural gas as well as whether the changes in flow rate of TEG will increase or decree the rate at which water is removed from the wet natural gas feed. It has therefore been demonstrated that there is a significant effect of changing the flow rate of TEG on drying of natural gas. Properties of natural gas that could be affected as a result of the application of different TEG flow rate conditions ranges from wobbe index, calorific value (heating value), molecular weight, to water content, etc. These properties are critical during sales gas quality assurance. This thesis will therefore serve as a basis for conducting performance standards studies as information contained herein will guide technical authorities towards ensuring a seamless natural gas quality assurance reviews.

5.0 APPENDICES

Appendix A

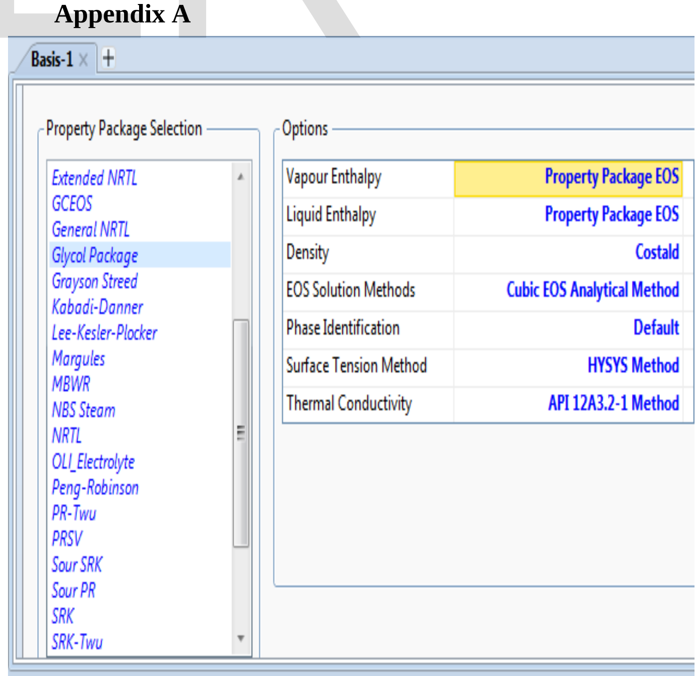

Fig. A1. Aspen Hysys Fluid Package Selection

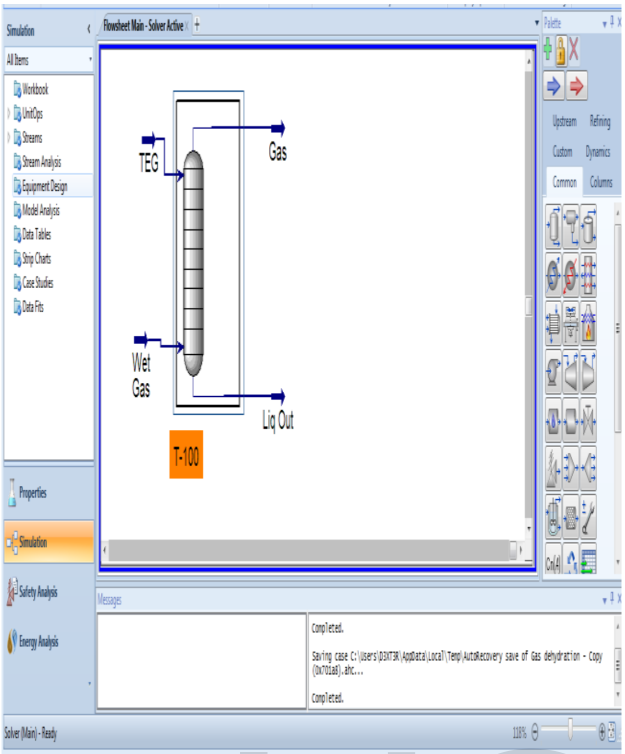

Fig. A2. Simulation Flow Sheet

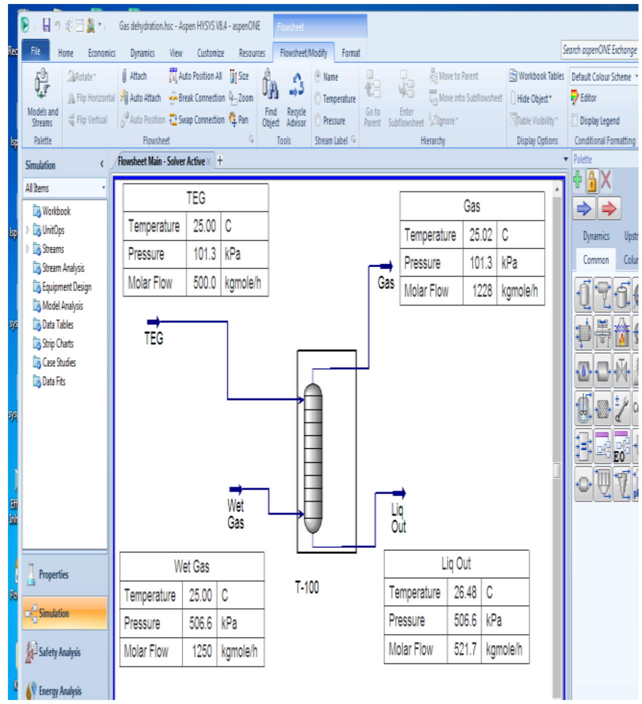

Fig. B2. Flowsheet for TEG Flow Rate of 500kgmol/h

Appendix B

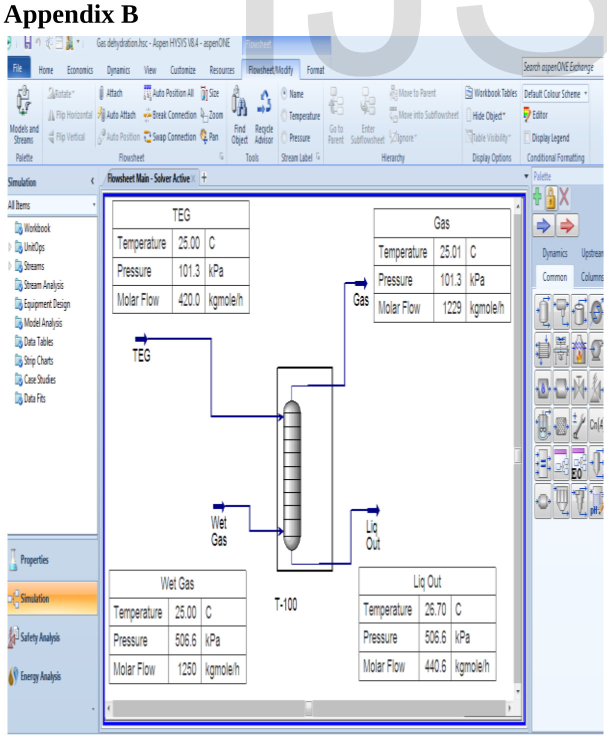

Fig. B1. Flowsheet for TEG Flow Rate of 420kgmol/h

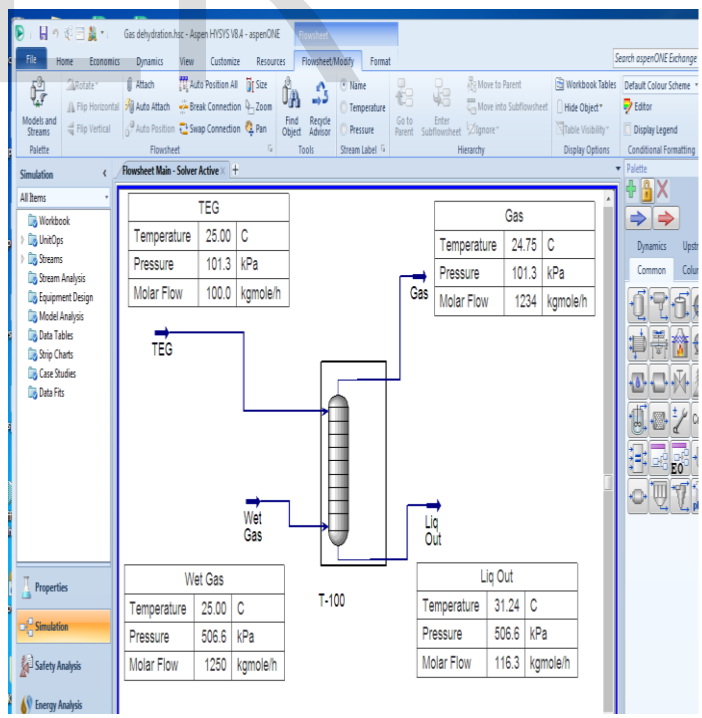

Fig. B3. Flow Sheet for Ratio of TEG Flow Rate at 100kgmol/h to Dry Gas Flow Rate

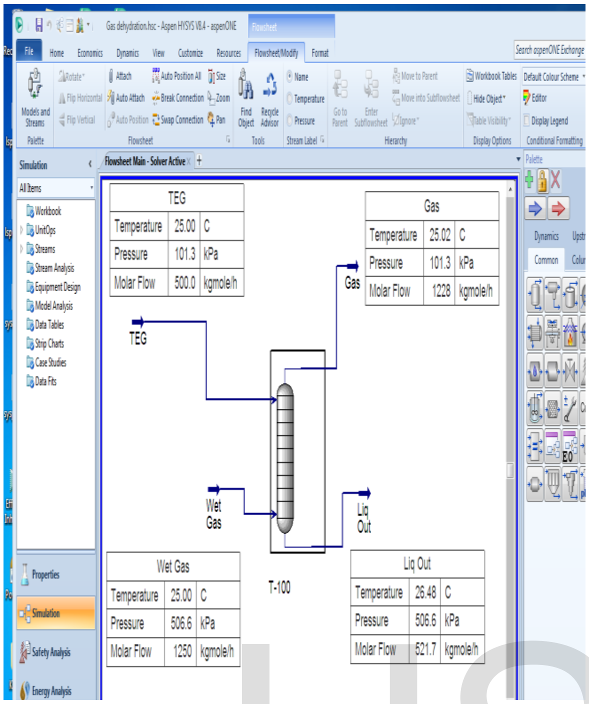

Fig. B4. Flow Sheet for Ratio of TEG Flow Rate at 100kgmol/h to Dry Gas Flow Rate

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