Effect Of Tri Ethylen Glycol (Teg) Concentration And Temperature Wet Gas Against Water Content Gas Outlet Glycol Contactor In Natural Gas Dehydration Process

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Abstract: One of the processing units located at the Natural Gas Processing Station is the Dehydration Unit (DHU). In the Dehydration Unit, there is a Glycol Contactor column which is the place for the absorption of water content from the wet gas that enters the column. Where the material used as an absorbent (absorbent) is Tri Ethylene Glycol and the substance that is absorbed (absorbate) is water vapour (H_2O). Based on the actual available data, there is an increase in water content in the sales gas (Dry Gas) of 1.47 lb / MMscf while the design is 0.05 lb / MMscf. This is because the water content in the inlet gas (wet gas) is greater than the design. namely 55.23 lb / MMscf and design 31.3 lb / MMscf. The amount of water content in wet gas and dry gas is influenced by the wet gas temperature and the concentration of Tri Ethylene Glycol (TEG). Based on the results of calculations and analysis, it can be said that the performance of the Glycol Contactor column has decreased water absorption efficiency when compared to the design.

Keywords : ***Tri Ethylen Glycol, Glycol Contactor, Water Content***

1. Introduction

Natural gas is a compound composed of a hydrocarbon component and also components of impurities. These impurities will not only lower the quality of natural gas, but will also interfere with the distribution process and the refinery of gas into other components. One of the impurities found in natural gas is water. Some of the water is dissolved in the gas and some is only included when the gas transfers from one place to another (Devold, H. 2013).

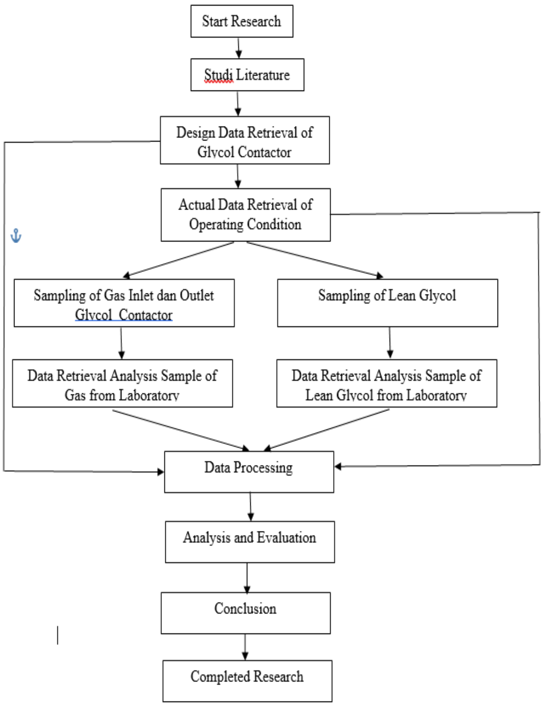
Water content in natural gas is very important, because water content is one of the factors determining product quality. If the water content is large, it is necessary to minimize it according to product standards accepted by consumers, it is reasonable that the presence of water content can have a negative impact. Not only on the product, but it can also have a negative impact on the natural gas processing plant itself so that gas dehydration is necessary (Ward, 2003).

In a previous study (Enggal Nurisman) Unsri, the study of calculating the flow rate of Triethylen Glycol (TEG) needed in the natural gas dehydration process, it was found that the higher the temperature of natural gas, the higher the water content contained in the natural gas so that the higher the flow rate. triethylene glycol which is needed in the natural gas dehydration process. The amount of TEG needed in the natural gas dehydration process at temperatures of 36 ^{0}c, 38 ^{0}c, 40 ^{0}c, 42 ^{0}c, 44 ^{0}c is 25.92 gal/day, 34.22 gal/day, 46.12 gal/day, and 63, 66 gal/day. Good quality natural gas is natural with a low water content of about 7 lb/mmscf.

Gas Dehydration is a process of removing the water content contained in the gas through an absorption process with the aim that the water vapor content is low, so that the dew point of the natural gas is low. The underlying reasons why it is necessary to perform gas dehydration are; natural gas containing water will form solid hydrate which will cause blockage of valves, shells, and pipes; if the water content is not separated then it will cause corrosion, especially if it meets (reacts) with CO2 or H2S; excess water will cause slug and allow erosion; water vapor increases the volume and decreases the heat value of the gas; the presence of water content causes icing in the piping system, especially in the refrigerant system; The presence of water content that exceeds the water threshold causes the product offspek.

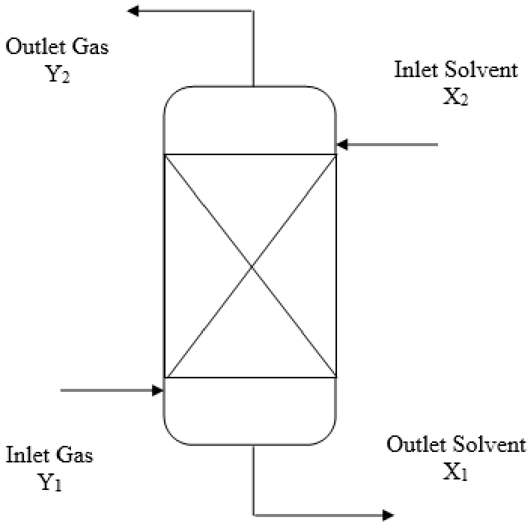
Several variables that affect the gas dehydration process are the temperature of the gas entering the contactor, the pressure of the gas entering the contactor, the flow rate of the gas entering the contactor, the concentration of glycol entering the contactor and the circulation rate of glycol, and the temperature of lean glycol entering the glycol contactor. Therefore, the glycol contactor has an important role in the gas purification process, it is very necessary to research the effect of the temperature of the wet gas entering the glycol contactor and the concentration of lean glycol as absorbent on the water content outlet of the glycol contactor in order to obtain the right operating conditions for the natural gas dehydration process

2. **Research Methodology**



Picture 3.1 Flow Figure Research

2.1 Stage of Calculating the Mass Balance



To complete the calculation of the mass balance on the Glycol Contactor, the following calculation steps are carried out: Menghitung fraksi mol komponen air (Fessenden, Ralp.J. 1988).

a.In The Inlet Gas (y_1 **)**

In Kay's rule, where to calculate the

$$\text{total moles of gas entering : } \frac{p\,v}{z\,R\,T} = n \qquad \text{pers. 1}$$

Then the mole value of the H_2O . component is determined (Fessenden, Ralp.J. 1988). :

$$n = \frac{m}{BM} \qquad \text{pers. 2}$$

$$n_{g1} = \frac{massa\ H_2O}{BM\ H_2O}$$

So, Equation 2 can be written :

$$n_{g1} = \frac{Q_1 \times I}{BM\ H_2O}$$

pers. 3

And then determine the mole fraction of the H_2O component in the intake gas (Fessenden, Ralp.J. 1988). :

$$y_1 = \frac{mol\ H_2O}{mol\ total}$$ pers. 4

And the equation can be written :

$$y_1 = \frac{n_{g1}}{G_1}$$

pers. 5

Remarks, P : Inlet Gas Pressure (Psia)
v : Gas Volume (ft^3) or Q_1
n : Mol of Inlet Gas (lbmol/jam) or G_1
T : Inlet Gas Temperature (R)
z : Gas Compressibility Factor
n_{g1} :Mol of Solute (Water) at Inlet Gas(lbmol/jam)
I : W*ater content* of Inlet Gas
(lb/MMscfd)
y_1 : Mol Fraction of Water Component
in the Inlet Gas

3. **Inlet Solvent (X_2)**

To Determine the mole fraction of a solvent whose %wt is known, the following equation can be used (Modul Kimia Analisis Dasar) :

$$\%(wt) = \frac{m\ TEG}{m\ total} \times 100\%$$

pers. 6

Formula : $m total = V \times d$

Then, the moles of the TEG component can be determined by the press. following:

$$n_p = \frac{\%(wt) \times m\ total}{BM\ TEG}$$

pers. 7

While for H_2O Component :

$$n_{p2} = \frac{(100\% - \%wt) \times m\ total}{BM\ H_2O}$$ pers. 8

$$x_2 = \frac{n_{p2}}{L_2} = \frac{n_{p2}}{n_{p2} + n_p} \qquad \text{pers.9}$$

Remarks, n_p : moles of TEG component in Solvent (lbmol/hour)
% wt : TEG Concentration
V : Volume of Solvent (ft^3) or q_2
n_{p2} : moles of Water component in Solvent (lbmol/hour)
d : Density of Solvent (lb/ft^3)
m total : Total Solvent mass (lb/jam) atau m_2
m TEG : Mass of TEG in Solven (lb/hour)
x_2 : Mole Fraction of the Water Component in the Inlet Solvent
L_2 : Moles of Inlet Solvent (lbmol/hour)

4. **Gas Outlet (Y_2)**

Based on the pres. 5, then the H2O component fraction can be written as follows :

$$y_2 = \frac{n_{g2}}{G_2} \qquad \text{pers. 10}$$

With the pers. 1 and pers. 3, then this equation can be written :

$$y_2 = \frac{(Q_2 \times O) \div BM\ H_2O}{\frac{P_2\ V_2}{z\ R\ T_2}}$$

Where V1 = Q1, then this equation can be written as follows :

$$y_2 = \frac{O \div BM\ H_2O}{\frac{P_2}{z\ R\ T_2}} \qquad \text{pers. 11}$$

a. Calculation of Water Absorb
To calculate of water absorbed in the absorption mass transfer operation, the following operating line equation can be used:

1. Determine of Operating Line (L_s/G_s)

$$L_s = L_2 \times (1 - x_2) \qquad \text{pers. 12}$$

$$G_s = G_1 \times (1 - y_1) \qquad \text{pers. 13}$$

$$(L_s/G_s) = \frac{L_2 \times (1 - x_2)}{G_1 \times (1 - y_1)} \qquad \text{pers. 14}$$

Remarks, G_s : moles of non-diffuse natural gas (lbmol/hour)
L_s : moles of non-diffuse solvent (lbmol/hour)
L_s/G_s : Operating Line
G_1 : Moles of Inlet Natural Gas (lbmol/hour)
L_2 : Moles of Inlet Solvent (lbmol/hour)
y_1 : Moles Fraction of Water in the Inlet Natural Gas
x_2 : Moles Fraction of Water in the Inlet Solvent (McCabe, W.L., Smith, J.C., and Harriot, P., 2005)

2.Determine the Concentration of Outlet Solvent

Using the operating line, it is possible to determine the mole fraction of the water component in the solvent (x_1) (McCabe, W.L., Smith, J.C., and Harriot, P., 2005).:

$$L_s / G_s = \frac{y_2 - y_1}{x_2 - x_1} \qquad \text{pers. 15}$$

Then the total moles of Outlet solvent will be obtained (L_1) (McCabe, W.L., Smith, J.C., and Harriot, P., 2005). :

$$L_1 = \frac{L_s}{1 - x_1} \qquad \text{pers. 16}$$

Then the number of moles of water in the Outlet Solvent (n_p1) can be written as (McCabe, W.L., Smith, J.C., and Harriot, P., 2005) :

$$n_{p1} = L_1 \times x_1 \qquad \text{pers. 17}$$

Then the mass of solvent will come out :

$$m_1 = mH_2O + mTEG$$
$$m_1 = (n_{p1} \times BM\ H_2O) + (n_p \times BM\ TEG), \qquad \text{pers. 18}$$

So, it can be calculated concentration of Outlet Solvent :

$$\% = \frac{m\ komponen}{m\ total} = \frac{m\ TEG}{m_1} \qquad \text{pers. 19}$$

Remarks, G_s : moles of non-diffuse natural gas (lbmol/hour)
L_s : moles of non-diffuse solvent (lbmol/hour)
y_1 : Moles Fraction of Water in the Inlet Natural Gas
y_2: Moles Fraction of Water in the Outlet Natural Gas
x_1 : Moles Fraction of Water in the Outlet Solvent
x_2 : Moles Fraction of Water in the Inlet Solvent
% : Concentration of Outlet Solvent
m_1 : Mass of Outlet Solvent (lb/hour)

3.Total Mass Balance (G_2)

$$\mathbf{L_1 + G_2 = L_2 + G_1} \qquad \text{pers. 20}$$

Remarks, L_1 : Flow rate of moles of Intlet Solvent (lbmol/hour)
L_2 : Flow rate of moles of Outlet Solvent (lbmol/hour)
G_1 : Flow Rate of mol of Inlet Gas (lbmol/hour)
G_2 : Flow Rate of mol of Outlet Gas (lbmol/hour) (E. Treybal Robert. 1981)

4. Mass Balance of Water Component

$$L_1 \times x_1 + G_2 \times y_2 = L_2 \times x_2 + G_1 \times y_1 \qquad \text{pers. 21}$$

Remarks, L_1 : Flow rate of moles of Intlet Solvent (lbmol/hour)
L_2 : Flow rate of moles of Outlet Solvent (lbmol/hour)
G_1 : Flow Rate of mol of Inlet Gas (lbmol/hour)
G_2 : Flow Rate of mol of Outlet Gas (lbmol/hour)
y_1 : Mol Fraction of Solute (Water) in the Inlet Gas
y_2 : Mol Fraction of Solute (Water) in the Outlet Gas
x_1 : Mol Fraction of Solute (Water) in the Outlet Solvent
x_2 : Mol Fraction of Solute (Water) in the Inlet Solvent (E. Treybal Robert.1981)

5. Total Water Absorbed (W)

It can be determined by finding the difference between the mass of water in the outgoing solvent and the incoming solvent or the difference in the mass of the incoming gas water with the outgoing gas.

$$W_{G1} = G_1 \times y_1 \times BM.H_2O \quad \text{pers. 22}$$

$$W_{G2} = G_2 \times y_2 \times BM.H_2O \quad \text{pers. 23}$$

$$W = W_{G1} - W_{G2} \quad \text{pers. 24}$$

Remarks, W_{G1} : Mass Water in the Inlet Gas (lb/hour)
W_{G2} : Mass Water in the Outlet Gas (lb/hour)
W : Mass of Water Absorb (lb/hour)
G_1 : Flow Rate of Moles Inlet Gas (lbmol/hour)
G_2 : Flow Rate of Moles Outlet Gas (lbmol/hour)
y_1 : Mol Fraction of Solute (Water) in the Inlet Gas
y_2 : Mol Fraction of Solute (Water) in the Outlet Gas

Calculating the efficiency of water absorption to calculate the efficiency of water absorption, we can use a method by directly comparing the mass of water absorbed with the mass of water contained in the incoming natural gas.

$$\eta = \frac{W_{G1} - W_{G2}}{W_{G1}} \times 100\% = \frac{W}{W_{G1}} \times 100\% \quad \text{pers. 25}$$

Remarks, η : Efficiency of Absorption
W : Absorp Water Mass (lb/jam)
W_{G1} : The mass of water in the gas inlet (lb/jam)
W_{G2} : The mass of water in the gas Outlet (lb/jam) (Chaudhuri, UR. 2011).

5. Result and Discussion

Table 4.1 Data Design Operational and Calculate Result

Parameter	Desain	Tanggal 12 April 2021	17 April 2021	21 April 2021	27 April 2021	30 April 2021
Temperatur *Wet gas* (°F)	70	80	81	82	86,75	88
Tekanan *Wet gas* (psia)	775	740	738	736	730	735
***Water Content wet gas* (lb/MMscf)**	31,3	46,079	48,778	51,484	62,417	67,425
Fraksi Mol air *wet gas*	1.07821 x 10^{-5}	1,69272 x 10^{-5}	1,8041 x 10^{-5}	1,91401 x 10^{-5}	2,36198 x 10^{-5}	2,55791 x 10^{-5}
***Water Content Dry gas* (lb/MMscf)**	0,05	1,61	1,69	1,50	1,38	1,19
Fraksi Mol air *Dry gas*	2,7778 x 10^{-5}	5,8927 x 10^{-5}	6,2252 x 10^{-5}	5,534 x 10^{-5}	5,1183 x 10^{-5}	4,842 x 10^{-5}
Konsentrasi *Lean TEG* (% weight)	99,99	99,9274	99,9072	99,8801	99,933	99,9487
Konsentrasi *Rich TEG* (% weight)	96,35	95,481	95,069	94,744	92,947	91,872
Efisiensi penyerapan (%)	99,84	96,518	96,549	97,108	97,833	98,247
Air terserap (lb/jam)	78,7726	116,170	123,759	129,465	157,263	174,435

From the actual wet gas temperature in table 4.1 (Sivall, Inc. 1982.), it is known that the actual wet gas temperature is much higher than the design data and increases every day. However, the actual pressure data shows much lower than the design data and decreases every day, so the actual water content obtained based on the Dew Point Control measuring instrument is greater than the design. This is because the higher the operating temperature, the more water in the gas content is evaporated, the actual water content obtained is in the range of 46-67 lb/MMscf. For more details can be seen in figure 1 below:

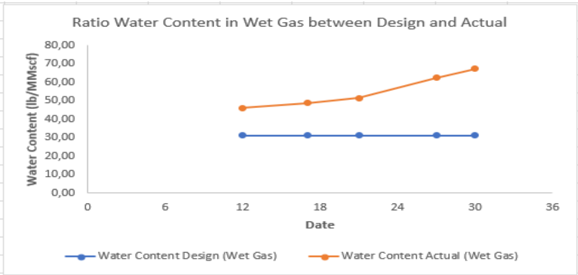


Figure 1 : Ratio Water Content in Wet Gas between Design and Actual

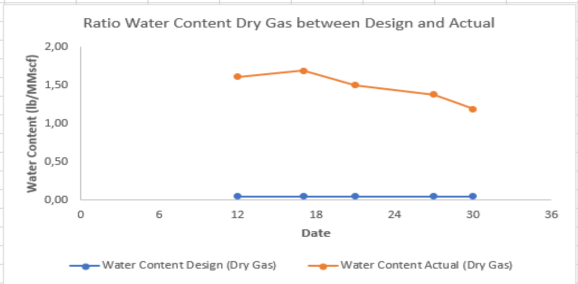


Figure 2 ***:*** Ratio Water Content in Dry Gas between Design and Actual

Based on the figure above, it can be seen that based on actual data and calculation results, the water content and mole fraction of the water component in the dry gas is greater than the design. This is because the water content contained in the wet gas entering the Glycol Contactor column is actually greater than the design, so that the water absorption process that occurs is more difficult to absorb excess water content and causes water content and mole fraction of components. water in dry gas obtained in actual and calculation is greater. The actual water content of dry gas obtained is in the range of 1.1-1.6 lb/MMscf, as a result, the large water content in dry gas causes icing in the refrigerant system which can inhibit gas flow rate.

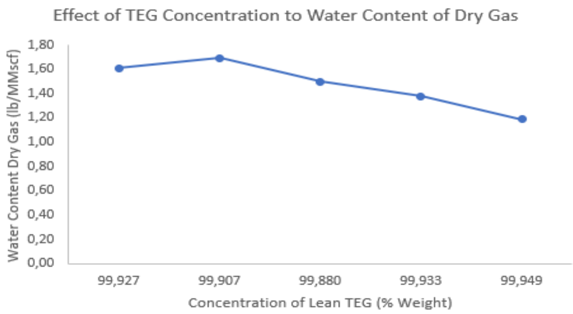


Figure 3: Effect of TEG Concentration to Water Content of Dry gas

Based on the figure above, it can be seen that the concentration of TEG affects the absorption of water content in wet gas. The higher the TEG concentration, the more water is absorbed in the Rich TEG and the drier the gas that comes out of the Glycol Contactor or the smaller the water content in the Dry gas. From the calculation results, the amount of water absorbed is 116-174 lb/hour with a concentration of Tri Ethylen Glycol (TEG) used of 99.88 - 99.94%.

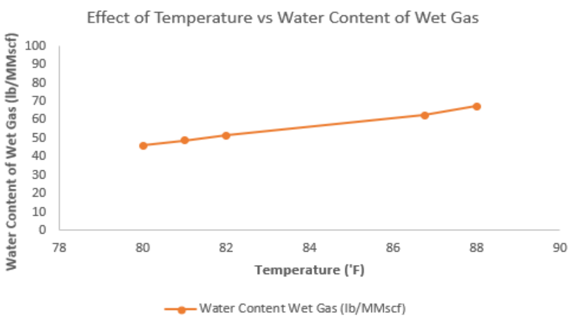


Figure 4: Effect of Temperature Wet Gas to Water Content of Wet Gas

6. Conclusion

Based on the results of research data actual, calculation and discussion then it can be concluded as following :

1. The actual water content of the gas entering the Glycol Contactor (Wet gas) column is known to be greater than the design, with the actual average water content of 55.23 lb/MMscf while the design is 31.3 lb/MMscf. . So that the absorption efficiency based on the calculation results is lower because the Lean TEG function in absorbing water is greater.

2. Based on the results of the analysis, it is known that the higher the concentration of Tri Ethylene Glycol used as an absorbent in the natural gas dehydration process, the higher the water absorption process in the glycol contactor column which results in lower water content in the gas outlet glycol contactor.

3. The performance of the Glycol Contactor column is currently experiencing a decrease in absorption efficiency. Because the efficiency obtained from the calculation results is lower than the design, ranging from 96-98%.

4. Based on the results of the analysis, it is known that the factors that affect the water content of the wet gas and the efficiency of absorption in the Glycol Contacor column include the temperature of the wet gas entering the Glycol Contactor column and the concentration of Tri Ethylen Glycol used as an absorbent.

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