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The Economic Comparison Between Dry Natural Gas And Nitrogen Gas For Stripping Water Vapor From Glycol In The Gas Dehydration Process

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Abstract: *Natural gas isa substantial energy source among other sources of fossil fuels. It is usually produced saturated with water vapor under production conditions. The natural gas dehydration is very paramount in the gas industry to stripthe water vapor existing in the gas production, at low-temperature conditions that may plug the system because of hydrate formation in pipelines. Totake off water vapor from natural gas flow usestriethylene glycol (TEG) in the gas dehydration process. In the glycol method, the wet gas is contactwith leanglycolinan absorber to dehydrate naturalgas and the rich glycol will be recovered and used again. This paper deals with stripping gas in the regenerator of glycol dehydration package with part of dry natural gas instead of nitrogen for stripping water vapor from triethylene glycol and studying the economic comparison between both of them by using modeling and simulation with HYSYS program. The two methods were investigated and evaluated to choose the optimal one with respect to the capital and utility costs, provided that keeping the same specifications and quantity of the glycol purity.In addition, the wet gas from the stripping process can be used to operate texsteam pumps and compressors or recycle with wet gas feed. The model has been built according to the actual process flow diagram. Finally, the results of this model could be considered as a basis on which a new heat and material balance will be developed for the plant.*

Keywords: *Natural gas: glycol dehydration process: watervapor: stripping gas: simulation: HYSYS.*

I. Introduction

The dehydration process of natural gasis one of the most prominent processing [1]. The gas is dried to preventproblemsrelatedto pipeline transportation and treatment process of wet gas that includesproblems as corrosion, water condensation which leads to plugs in pipelines [1, 2, 3].Natural gasis driedto be compatiblewith salesgas specifications or other gas processes such as gas hydrocarbon liquidrecovery. In particular, wetness levels in natural gas should preserveata lower of sales gas specification so as to avoidthe formationof gas hydrate and minimize corrosion in pipeline transportation [4, 5, 6].The methods used for gas dehydration are absorption, adsorption, membrane processes, refrigeration and low temperature separation (LTS) method [7].In the glycol process, water vapor is separated by a solvent with a powerful affinity for water as absorption process. The lean glycol takes off the water vapor from the wet gas in an absorption column (called contractor). Before the rich glycol that associated with water vapor recycled to the contactor must be regenerated in the regeneration column [8].In the regeneration the glycol distilling and thus separate the water vapors. In the glycol absorption it is possible to depressthe water contents in the gas down to approximately 10 ppmv, based on the lean glycol purity. The utilization of TEG (triethylene glycol) is the most eligible in the dehydration processes because having the following properties; High absorption efficiency, easy and economic regeneration, non-corrosive and non-toxic, No operational problems when used in high concentrations, no interaction with the hydrocarbon portion of the gas, and no contamination by acid gases [9].The adsorption is one of the other methods of dehydration process that operate with two- bed system where the beds are loadedwith substance that adsorbs as silica gel. In one of the adsorbers,the gas is driven through it and thewater vapor isseparated.Meantime,hotdry gas blowing through the other adsorberthen thisused gas is chilled and the water is condensed. The condensedwater is removed and thegas is back to the wet gas feed. In membrane processes,a membrane used to separate water vapor from the wet gas feed, this process produces dry gas with water vapor content 20-100 ppmv[10].There is a problemin utilization of membrane processes are not economical compared tothe absorption by glycol at a flow rateless than 1.5106 Nm3/d (56 MMscfd) but over this flow the process is not economically [10]. The refrigeration method of wet gas is a low cost compared to the other methodsof the gas dehydration where the wet gas cooled and the water vapor condensedto water in two phase separator. This methodcan be managed numerous times, butthere are problems in the usage of this *method are the effect ofthis process is at high pressure onlyandTheamount of watervapor in the feed of wet gas are not separatedbecause the refrigeration process is often used before the other dehydration processes.*

II. Process Description

The absorption process into a liquid desiccant is the most greatused in dehydration process that include thewater vapor separation by (as glycol)absorption processes[11]. To keep the process continuity, the rich glycol must be regeneratedin the stripper column (regenerator) to recover the desiccant. The rich glycolis stripped in the regenerator column by using steam, some dry stripping gas like air or nitrogenas a medium. At high temperature and low pressure the operating conditionof the stripper is efficient[12].Butthe absorber is efficient at low temperature and high pressure. The flow sheet simulation ofthe dehydration process of natural gashas been simulated bythe ASPEN HYSYS program illustrated in Fig. 1. This flow sheet illustrates a typical dehydration unit by glycol and matches many of the dehydration units in current use in the Petroleum Companies. Theoperating conditions of the base-case detailed in this process have been given elsewhere. Therich glycolleaved the bottom of the contactor, flashed by throttling valve and flow to two phase separator (flash tank) to minimize pressure before the flow to the regenerator unit, where the absorbed substances are removed from theglycol. In the TEG - dehydration process can be split into two main parts, gas dehydration and glycol regeneration. In the gas dehydration part, wet gas is dehydrated by the counter current absorption process by Triethyleneglycol (TEG); glycol and in the regeneration part, water vapor is separated from TEG and afterregeneration fresh (lean) TEG is fed back to contractor tower. In general a dehydration process is included facility as: absorption column, flash tank, heat exchangers, inlet scrubber and regenerator column, (Figure 1). During the process, the wet gasand the lean glycolget into thebottom side and the top side ofthe absorption column respectively, after the wet gas flowing through the inlet scrubber (optional). In most cases using an inlet scrubber depends on the amount of the liquid present in the wet gas. The scrubber importance,separates both water and hydrocarbons as free liquids,decreases the amount of free water that removes in the absorption (contactor) column, this also minimizes the absorption column size and reduce the TEG required in thisprocess. In effective dehydration process [13] the temperature difference between the two streams enters the absorption column should be around 10~15 degree. The hot lean TEG fed to the contactor column generally has a higher temperature that needs to be reduced and a gas glycol exchanger is used where the lean TEG exchanges heat with the gas outlet from the regeneratortower, then flow through the flash separatorwhich used for extraction of higher hydrocarbongases that absorbed in TEG before therich glycolflow to the stripperwhich is a distillation column used to separate water vapor from the TEG. The rich TEG is preheated in another heat exchanger before it flew to the regeneration column to reduce energy consumed in the regenerator column. The regenerated TEG exchanges heat with an incoming rich stream that eventually decreases its temperature, then cooled to its original temperature by cooler using and lastly the lean TEG is fed to the contactor tower. The glycol rate out of the glycol contactor is controlled by a level control valve and the inlet flow rate of glycol is determined the TEG pump discharge. The glycol temperature returning from the regeneration skid is monitored. The temperature of the dehydration system varies in a close range from 37.7 to 60oC. The dew point of the outlet gas from the contactor tower is monitored through a moisture analyzer.

In the new modification of the dehydration process,a splitter is used to split dry gas producedand utilizea small amount of itas stripping gas in the regeneratorcolumn to separate water vapor from TEG solvent instead of nitrogen used in most processes to save energy consumed and capital cost. Use storage tank for settling TEG glycol and remove any vapors before pumping to the absorber column.

2.1. Dehydration plant design by ASPEN HYSYS simulation

In our plant design of dehydration process will be given from some plant specifications.The temperature of inlet wetted gas varieswith the temperature in the absorption column[14,15]. The temperature and pressure of TEG differ from the absorption column specification, first the TEG pumpedand then the temperature is lowered.The absorber column consists of five plates without condenser and reboiler. The lean TEG inlet and dry gas outlet are at the top ofthe column, the rich TEG outlet and wet gas inlet are at the bottom of the column.

The TEG flow iscontrolled by the water vapor contents analyzed in the wet gas, with a flow of 0.025 m3 TEG/kg Water. The pressure of the rich TEG is lowered by a throttling valve after the absorber column, and then exchanges its temperature with the outlet gases from the regenerator condenser column.The temperatureof the rich TEG is increased and hydrocarbons dissolvedin the TEG is separated in the flash separator, then flew to second heat exchanger to exchange with the higher temperature outlet regenerated glycol for energy saving.The regenerator column consists of five plates, plus a condenser and a reboiler and the rich TEGfeeding to the regenerator on the middle plate. For dehydration of natural gas by absorption method requires a TEG purity of 99.6 wt% so stripped gasleads to the reboiler of the column. In addition, the temperaturerequired for the reboiler is 205 °C to avoid TEG decomposition and lost in the gas phase.The outlet lean TEG from the regenerator column is exchanging its heat to become coolonce again to 85°C to conserve the pump. If TEG lost *to the gas phase in the contactor column or the regenerator column must be install make up the system to complete the loss in TEG. Lastly the lean TEG is recycled to the absorption column.*

2.2 Dehydration process case study

The stripping water vapor from glycol in the natural gas dehydration plant by using part of dry natural gas produced instead of nitrogen in a dehydration gas plant. Table I illustrates the composition analysis of feed wet gas. TableII illustrates the field conditions in our case study.

Table I:the composition analysis of feed wet gas.

Component	***Mole fraction %***
Methane	0.6711
Ethane	0.1266
Propane	0..085
i-butane	0.0152
n-butane	0.0255
i-pentane	0.0035
n-pentane	0.0035
n-hexane	0.0056
n-heptane	000
n-octane	000
n-Nonane	000
n-decane	000
Water	0.0033
Nitrogen	0.007
Carbon dioxide	0.061
Hydrogen sulphide	0.00000

Table II: the field conditions of a wet gas.

Condition	***Value***
Vapor / Phase Fraction	1
Temperature [^{o}C]	58.2
Pressure [KPa]	6780
Molar Flow [kgmole/hr]	6220.17
Mass Flow [kg/hr]	151871.9

In the contactor column is to create the simulation of the gas streams. The percentage of water content in the wet gas is used to determine the TEG flow rate. In our case the water flow rate is 373.4kg/h and thus making the TEG flow rateis 2.69m3/h. The flow rate of the TEG now is calculated, the pressure and temperature of TEGmust be as required criterion for the absorber column. When the TEG and the gas outlet streams are added to the absorber column the ASPEN HYSYS can be now calculated. The flow of stripping gas added to the regenerator is calculated and determined by the glycol flow,by this flow ASPEN HYSYS program design states the stream on the side of the regenerator column and this focuseson our process modification.

In the simulation of regenerator column must be defined two variables which indicate by two degrees of freedom. This two design variables are given, namely the condenser temperature and the reboiler temperature. The target of this design is estimated this item, the first estimate is the purity of lean TEG, the mass fraction of TEG in the liquid phase in the reboiler is established in 0.996, and a second estimate is the overall vapor flow rate from the condenser. The calculation of this estimate is as the overall flow rate of stripping gas into the regenerator plus the flow rate of water vapor in the Triethylene-glycol. The overall vapor flow estimate is calculated as mass flow, giving an estimated flow of 701 kg/h and third estimate is given by the reflux ratio from the condenser. This value is not estimated but calculated by HYSYS.

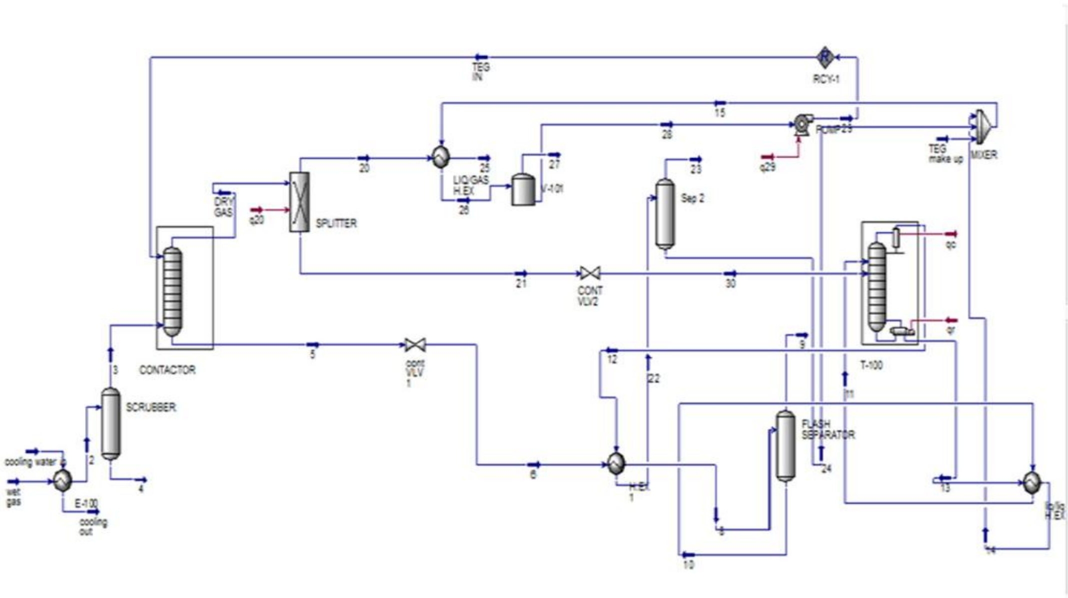

Figure 1: Typical Gas dehydration system

III. Results And Discussion

3.1 Proposed Options for a TEG dehydration gas plant

There are two different options for stripping water vapor from glycol in the natural gas dehydration plant by using small parts of dry natural gas produced or nitrogen gasthat is applied in the process modeling of the plant. The results of this model are considered a basis for new heat and material balances developed for the plant. The two options are as follows:-

Option No. 1:

In the field the stripping water vapor from glycol in the natural gas dehydration plant was made by using nitrogen gas. The quantity of nitrogen gas used in regeneration column is 336.1 kg/hr, temperature and pressure of are -194.3^{0}C and 120kpa and purity of TEG glycol not less than 99.6%.Table III illustrates the results of regeneration simulation by using nitrogen gas as a stripping gas.

Table III: the regeneration with nitrogen gas as stripping gas.

Name	***Reboiler Condition***	***lean TEG from regenerator***	***Rich TEG to regenerator***	***Stripping nitrogen gas to regenerator***
Pressure [KPa]	120	120	120	120
Temperature [^{0}C]	205	205	165	-194.3
Mass Flow [kg/h]	596.1	7756.6	8120.5	336.1
Vapor / Fraction	1	0	0.088022	1
Molar Enthalpy [kJ/kgmole]	-99602.7	-728233	-621275	-6337.65

Option No. 2:

In our case of dehydration of natural gas, small part of dry natural gas produced was used as a stripping gas in regeneration column instead of nitrogen gas. The quantity of dry gas used as stripping gas was 200kg/hr, temperature and pressure of are -14.50C and 140kpa. The purity of triethylene glycol (TEG) produced from regeneration column is 99.6%,and then TEG recycled back to contactor column. Table IV illustrates the results of regeneration simulation by using part of dry natural gas as a stripping gas.

Table IV: the regeneration with part of dry natural gas produced as a stripping gas.

Name	***Reboiler Condition***	***lean TEG from regenerator***	***Rich TEG to regenerator***	***Stripping natural gas to regenerator***
Pressure [KPa]	120	120	120	140
Temperature [C]	204.9	204.9	165	-14.5
Mass Flow [kg/h]	454.1	7833.9	8178.7	200.2
Vapor Fraction	1	0	0.090656	0.946707
Molar Enthalpy [kJ/kgmole]	-171030	-723462	-620020	-96901.2

This study states the main points of each option, the capital; utility cost and amount of stripping gas andthe amount of water vapor stripped which need in a TEG dehydration package as a stripping gas in a regeneration column in natural gas dehydration plant. The comparisons between dry natural gas and nitrogen gas are illustrated in Table IIV.
In the second option, the capital cost is 5,089,310USD, utility cost is 245,992 USD,purity of TEG is 99.7 % and the quantity of stripping natural gas is 200.2 (Kg/hr). In the firstoption,the capital cost is 5,149,320 USD, utility cost is 249,424USD, purity of TEG is 99.7 %and the quantity of stripping nitrogen gas is 336.1Kg/hr.
For comparison between the two options, the second option is selected for the following considerations as in table IIV:

- *Lowest capital cost*
- *Lowest utilities cost*
- *Lowest quantity of stripping gas*
- *Lowest energy consumption.*

Table IIV:the comparisons between dry natural gas produced and nitrogen gas in the dehydration package as stripping gas in regeneration column.

Item	***Stripping in regeneration with dry natural gas***	***Stripping in regeneration with nitrogen***	***Difference between nitrogen and natural gas***
Capital Cost (USD)	5,089,310	5,149,320	60010 (Reduced cost)
Utility cost (USD)	245,992	249,424	3432 (Reduced cost)
Purity of TEG (%)	99.7	99.7	Equal
Quantity of stripping gas(Kg/h)	200.2	336.1	135.9
Vapor Flow(water vapor + stripping gas) Kg/h	701	700	155

IV. Conclusion

This paper investigates the economic effect of using dry natural gas from the dehydration process instead of nitrogen gas as a stripping gas in regenerator column, where using of dry natural gas were introduced 60010 USD saving in capital cost and 3432 USD saving in utility cost. The same of TEG purity is at the same conditions of two processes. In addition, the quantity of dry natural gas is lower than nitrogen gas as stripping gas, the same quantity of vapor flow (overhead product stream) from the regenerator. A steady state model of gas plant has been built in order to assess the operating process as well as the main equipment included in the plant. All results of process simulated extracted from the ASPEN HYSYS program.

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