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Natural Gas Dehydration Process Simulation and Optimization: A Case Study of Khurmala Field in Iraqi Kurdistan Region

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***Abstract*—**Natural gas is the most popular fossil fuel in the current era and future as well. Natural gas is existed in underground reservoirs so it may contain many of non-hydrocarbon components for instance, hydrogen sulfide, nitrogen and water vapor. These impurities are undesirable compounds and cause several technical problems for example, corrosion and environment pollution. Therefore, these impurities should be reduce or removed from natural gas stream. Khurmala dome is located in southwest Erbil-Kurdistan region. The Kurdistan region government has paid great attention for this dome to provide the fuel for Kurdistan region. However, the Khurmala associated natural gas is currently flaring at the field. Moreover, nowadays there is a plan to recover and trade this gas and to use it either as feedstock to power station or to sell it in global market. However, the laboratory analysis has showed that the Khurmala sour gas has huge quantities of H2S about (5.3%) and CO_2 about (4.4%). Indeed, Khurmala gas sweetening process has been removed in previous study by using Aspen HYSYS. However, Khurmala sweet gas still contents some quintets of water about 23 ppm in sweet gas stream. This amount of water should be removed or reduced. Indeed, water content in natural gas cause several technical problems such as hydrates and corrosion. Therefore, this study aims to simulate the prospective Khurmala gas dehydration process by using Aspen HYSYS V. 7.3 program. Moreover, the simulation process succeeded in reducing the water content to less than 0.1ppm. In addition, the simulation work is also achieved process optimization by using several desiccant types for example, TEG and DEG and it also study the relationship between absorbents type and its circulation rate with HCs losses from glycol regenerator tower.

***Keywords*—**Aspen Hysys, Process simulation, gas dehydration, process optimization.

I. INTRODUCTION

THE demand of natural gas in recent decade has been dramatic. Natural gas poses a huge rule in the recent world economy and development. However, natural gas is existed in deep underground reservoir under certain temperature and pressure. Therefore, it may content several of non-hydrocarbon components for instance, carbon dioxide, nitrogen and water vapor. Infect, Natural gas to be transported by gas pipelines or processed should meet certain specifications for example, H_2S must be reduced to less than 4ppm [1]. Indeed, Khurmala dome is the northern most domes of the Kirkuk oil fields structure. Moreover, the Dome is located approximately 20 kilometers by 8 kilometers. However, the Dome has not developed until 2003. Nowadays Khurmala field is considered as main fuel source for Iraqi Kurdistan region KAR [2]. In fact, Khurmala associated natural gas is currently flared at the field. There is a plan to recover and traded this gas to use it either as feedstock to power station or to sell it in global market. However, the laboratory analysis has showed that the Khurmala natural gas has huge quantities of H_2S about (5.3%) and CO_2 about (4.4%) [3]. Khurmala sweetening process has been done in previous study by using Aspen Hysys. However, Khurmala sweet gas still wet and content considerable amounts of water vapor which it may lead to several technical problems such as, hydrate formation and corrosion. Indeed, water vapor in natural gas should be reduced or removed and the main reasons for removing of water from natural could be sumirized as following: Water content of natural gas decreases of its heat value, liquid water in natural gas pipelines potentially causes slugging flow conditions resulting in lower flow efficiency of the pipelines [4]. In most commercial hydrocarbon processes, the presence of water may cause side reactions, foaming or catalyst deactivation. Therefore, to prevent such problems, natural gas treating is unavoidable. There are different methods for water treating of natural gas for example, adsorption, absorption, membrane process, methanol process and refrigeration [5]. Among mentioned methods absorption, which is called dehydration and use liquid solvent as an absorbent, is mostly common technique for treating of natural gas [4], [5]. Indeed, gas dehydration by glycol is capable to reduce the water content of natural gas less than 0.1ppm [6].

II. BASIC GLYCOL GAS DEHYDRATION PROCESS DESCRIPTION

Glycol process is considered the most successful and common process in gas industry field [4]. Indeed, this process is utilized glycol liquid desiccant as a chemical solvent to remove water vapor from natural gas stream. Moreover, glycol liquid has high affinity toward water vapor and there are several types of glycol that are used in glycol process for example, monoethylene Glycol MEG and dimethyl Glycol DEG [4]. Dehydration process is consisting of several operation units for instance, contactor tower, regenerator tower and heat exchanger. Fig. 1 shows typical gas dehydration process. During the process, lean glycol such as DEG enter to

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the absorption column at the top side which rich solvent is collected at the bottom of the column and will send to the regenerator [7]. Wet gas enters to the absorption column after passed through inlet scrubber. The scrubber removes free liquid and liquid droplets in the gas, both water and hydrocarbons (removing liquid in the scrubber decrease the amount of water that has to remove in the absorption column, and this also decrease the size of the column and therefore decrease the TEG needed in process) [6], [7]. Heat exchanger uses for cooling of wet gas before enter to scrubber. Rich TEG passes through a coil, which is used as reflux at the top of the absorption column; to increase its temperature. A tree phase flash tank uses for removal of absorbed acidic gases and hydrocarbons in TEG before rich solvent enter to the regenerator, which is a distillation column, and separate the TEG and water content. Indeed, rich TEG is preheated in another heat exchanger before it fed to the regeneration section. At the end of the process cycle, the regenerated TEG will cool in the third step of heat exchanger and will back to the dehydration column for reuse [8].

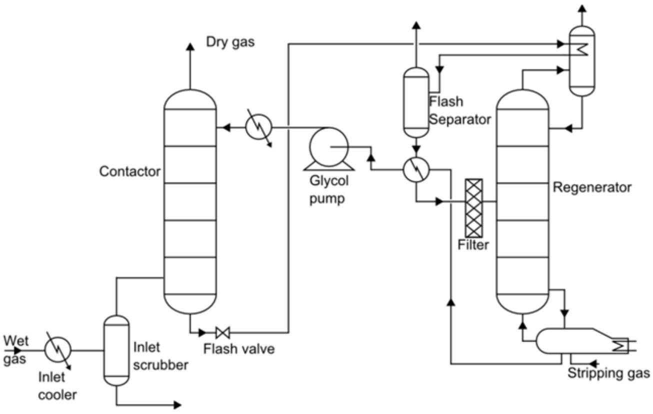


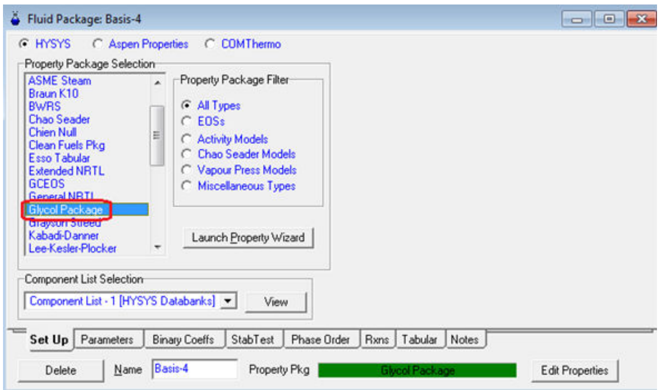
Fig. 1 Typical gas dehydration process

III. STEADY SATE SIMULATION, MODELING AND OPTIMIZATION

Table I shows Khurmala wet gas stream composition and operation condition [3]. The expected Khurmala gas dehydration plant is simulated by using Aspen HYSY V.7.3. The TEG is utilized as an aqueous absorbent to absorb water vapor from wet gas stream. The first step of simulation could be done by adding the gas stream compositions and conditions which it same data of this case study. Moreover, Hysys fluid package should be carefully chosen which it should be (Glycol Pkg) as shown in Fig. 2.

TABLE I
TABLE (1) KHURMALA RAW NATURAL GAS COMPOSITIONS AND OPERATION CONDITIONS

Components	Mole %
Methane	0.7164
Ethane	0.1565
Propane	0.0606
i-Butane	0.0153
n-Butane	0.0276
i-Pentane	0.0114
n-Pentane	0.0083
n-Hexane	0.0013
Water	0.0023
Carbon dioxide	0.00004
Nitrogen	Trace
Hydrogen sulfide	Trace
Operation condition	
Pressure	3555 K.pa
Temperature	40 °C
Flow rate	250MMSCFD


Fluid Package: Basis-4

● HYSYS ○ Aspen Properties ○ COMThermo

Property Package Selection: Glycol Package

Property Package Filter: ● All Types

Component List Selection: Component List - 1 [HYSYS Databanks]

Name: Basis-4

Property Pkg: Glycol Package

Fig. 2 Hysys fluid package menu

After achieving above, the simulation environment is entered. Moreover, simulation environment may consider the main simulation area, which it deals with the plant and shows the FPD for the process. It important to uses inlet gas separator to remove any undesirable impurities such as, solid particulars and liquids. Glycol contactor tower is also important part from the plant which it also need some specifications for example, streams temperature and pressure and the TEG concentration (99% is used) and Fig. 3 shows Glycol contactor menu. Moreover, rich glycol needs to be regenerate and that could be achieved by installing the glycol regenerator and Fig. 4 shows glycol regenerator menu.

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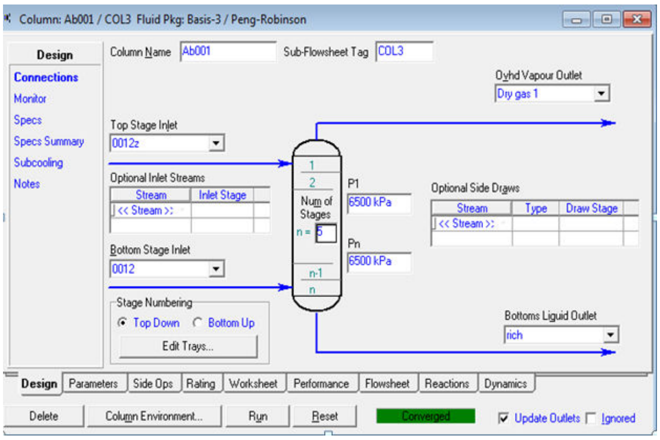

Column: Ab001 / COL3 Fluid Pkg: Basis-3 / Peng-Robinson

Column Name: Ab001
Sub-Flowsheet Tag: COL3
Ovhd Vapour Outlet: Dry gas 1
Top Stage Inlet: 0012z
Optional Inlet Streams:

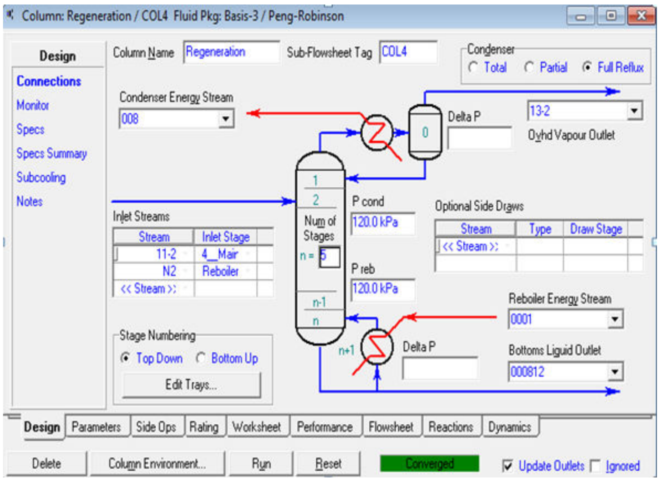
Stream	Inlet Stage
<< Stream >>	

Bottom Stage Inlet: 0012
Stage Numbering: ● Top Down ○ Bottom Up
P1: 6500 kPa
Pn: 6500 kPa
Num of Stages: n = 5
Optional Side Draws:

Stream	Type	Draw Stage
<< Stream >>		

Bottoms Liquid Outlet: rich
Converged
☑ Update Outlets ☐ Ignored

Fig. 3 Amine contactor menu


Column: Regeneration / COL4 Fluid Pkg: Basis-3 / Peng-Robinson

Column Name: Regeneration
Sub-Flowsheet Tag: COL4
Condenser: ○ Total ○ Partial ● Full Reflux
Condenser Energy Stream: 008
Delta P: 0
Ovhd Vapour Outlet: 13-2
Inlet Streams:

Stream	Inlet Stage
11-2	4__Main
N2	Reboiler
<< Stream >>	

P cond: 120.0 kPa
P reb: 120.0 kPa
Num of Stages: n = 5
Optional Side Draws:

Stream	Type	Draw Stage
<< Stream >>		

Reboiler Energy Stream: 0001
Delta P:
Bottoms Liquid Outlet: 000812
Stage Numbering: ● Top Down ○ Bottom Up
Converged
☑ Update Outlets ☐ Ignored

Fig. 4 Amine regenerator menu

The simulation process done successfully and Fig. 5 shows process flow diagram of Khurmala gas dehydration plant. As it seems from Fig. 5 several process unites are used in glycol process. Infect, installing flash separator for rich glycol is quite important in order to avoid any technical problems. In addition, water make up stream should be added with a mixer to the process. Infect, glycol concentration may be built up in the process because of water and amine losses with dry gas. Therefore, water makes up stream will maintain and support the concentration of TEG at acceptable value. The simulation process done and the process achieved high water removal that it will be discussed in result and discussion part. To make up the lost TEG the gas stream from the contactor, separator and regenerator is entered into a component splitter. In the component splitter the TEG is separated from the gas, creating a stream of pure TEG that is transferred back to the TEG stream. A mixer is required to mix the recovered TEG with the TEG from the regenerator and Fig. 6 shows splitter element menu.

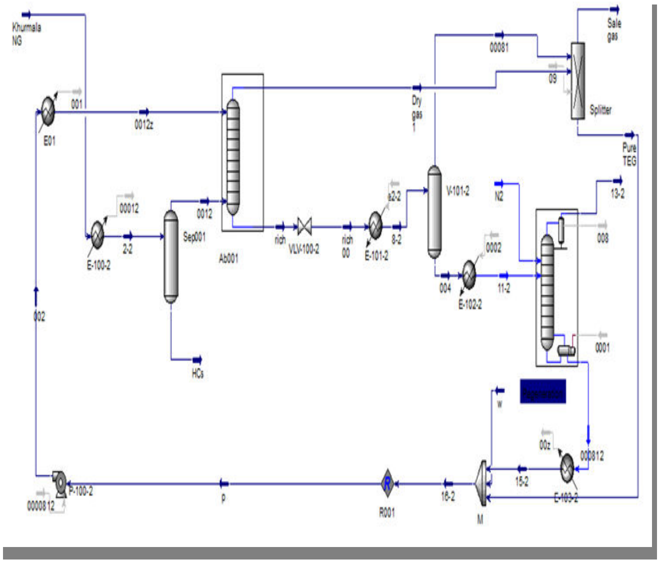
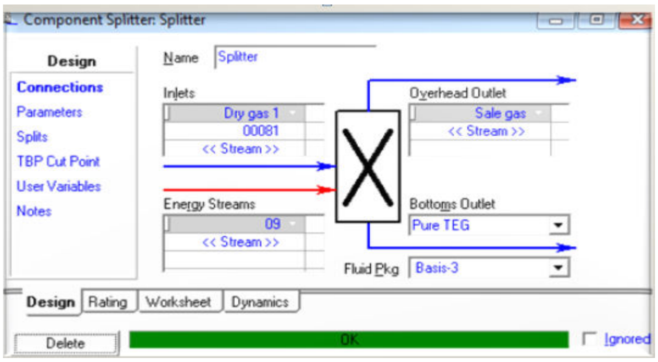


Fig. 5 Process flow diagram of Khurmala gas dehydration plant


Component Splitter: Splitter

Name: Splitter
Inlets:

Dry gas 1
00081
<< Stream >>

Energy Streams:

09
<< Stream >>

Overhead Outlet:

Sale gas
<< Stream >>

Bottoms Outlet: Pure TEG
Fluid Pkg: Basis-3
OK
☐ Ignored

Fig. 6 Glycol splitter menu

The TEG from the regenerator is cooled and recycled back to the TEG inlet stream. To do this a logical recycle operator must be inserted between the two streams. There is a problem with the recycling of the TEG; this is that small amounts of TEG are lost from the system in the gas flow from the contactor, separator and regenerator. The lost TEG must be replaced, or less TEG than required is recycled to make up the lost TEG the gas stream from the contactor, separator and regenerator is entered into a component splitter. In the component splitter the TEG is separated from the gas, creating a stream of pure TEG that is transferred back to the TEG stream. A mixer is required to mix the recovered TEG with the TEG from the regenerator. The glycol regenerator has five trays and provided with a condenser and a boiler. The rich glycol enters the regenerator on the middle tray. Glycol purities up to 99.9 wt% can be achieved by using stripping gas from the top of the stripping column. The stripping gas is usually nitrogen [9]. The water can be removed from the stripping gas by cooling it well below waters dew-point.

Process optimization is also achieved and the aim of this optimization work to examine several specific operation condition such as absorbents circulation rate on the process efficiency.

IV. RESULTS AND DISCUSSION

Khurmala gas dehydration plant is achieved by Aspen Hysys simulator and TEG is adopted firstly as absorbent liquid and it achieved good dehydration result at moderate circulation rate. However, process optimization is also carried out to find the most appropriate absorbent and circulation rate.

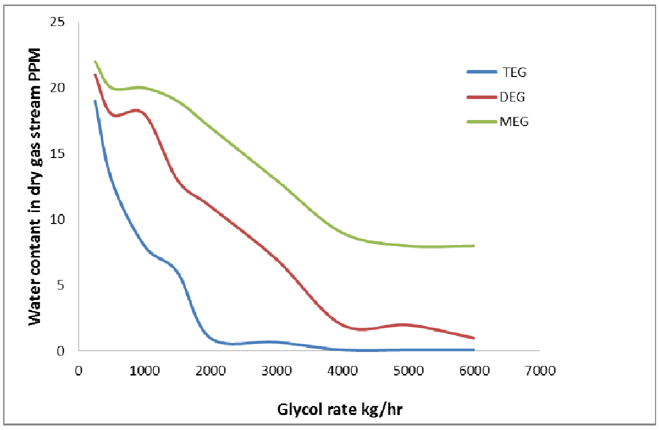


Fig. 7 Water content in the dehydrated gas for the different absorbents

From Fig. 7 it can be seen that the dehydration efficiency of the different glycol types are vary. MEG needs high flow rates of absorbent to obtain low water removal from the gas, and the lowest concentration possible is as high as about 7ppm and water removal reach equilibrium at about 4500kg/hr glycol circulation rate. However, DEG and TEG can remove huge quintets of water at low absorbent circulation rate. TEG achieved ideal water removal at 4000kg/hr which about 0.1ppm and then it reached equilibrium state.

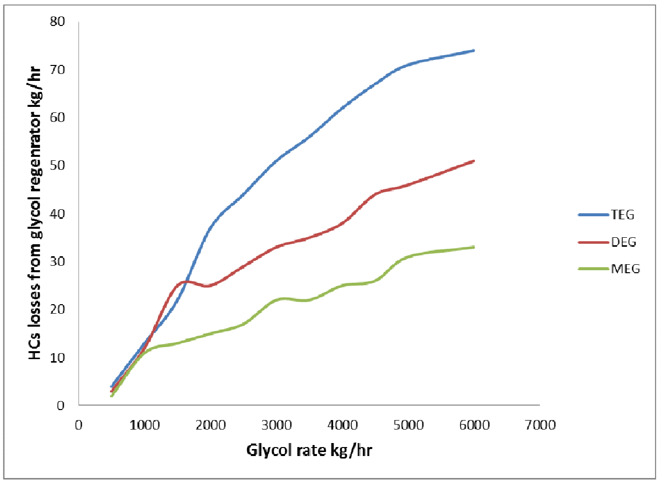


Fig. 8 Relationship between HCs losses from glycol regenerator and using different glycol types

From Fig. 8 can be seen be that TEG absorbs a lot more HCs than DEG and leads to more HCs losses from glycol regenerator as it circulation rate increased. As it can be seen from above figure increasing absorbent circulation rate for all glycol types leads to high HCs losses from glycol regenerator tower. However, MEG pose lowest HCs loses at almost circulation rate. DEG has moderate HCs losses.

V. CONCLUSION AND RECOMMENDATION

In conclusion, this work-study is achieved Khurmala gas dehydration process simulate and optimization by using Aspen HYSYS. It can be argued that Khurmala wet gas content some quintets of water vapor which it may lead to sever technical problems such as hydrate formation and pipeline corrosion. However, this problem could solve by installing gas dehydration unit for khurmala gas plant. Moreover, simulation work achieved high water removal. It could be argued that using TEG glycol at 4000kg/hr circulation rate can achieve good gas removal. However, TEG poses high HCs losses for glycol generator at mentioned circulation rate. Therefore, reducing TEG circulation rate or using DEG at 3500kg/hr is also achieve acceptable water removal result and low HCs losses rate. However, the most appropriate selection may be taken by the process designers and the process operators.

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