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# SIMULATION OF MOISTURE CONTENT REMOVAL IN RAW NATURAL GAS

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***Abstract***

*Natural gas may contain many of non-hydrocarbon components, for instance, hydrogen sulfide, nitrogen and water vapor. These impurities cause several technical problems such as corrosion and environmental pollution. Therefore, these impurities should be reduced or removed from raw natural gas stream. However, the laboratory analysis has showed that the sour gas has huge quantities of* $H_2S$ *about (5.3%) and* $CO_2$ *about (4.4%). Indeed, gas sweetening process has been removed in previous study by using Aspen HYSYS. However, sweet gas is still containing some quantities of water reach to more than 23 ppm in sweet gas stream. This amount of water should be removed or reduced. Indeed, water contents in natural gas cause several technical problems such as hydrates and corrosion. Therefore, this study aims at to simulate the prospective gas moisture removal process by using Aspen HYSYS software. Moreover, the simulation process succeeded in reducing the water content to less than 0.1ppm. In addition to that, the simulation approach achieved a process optimization by using several desiccant types such as, triethylene glycol (TEG) and diethylene glycol (DEG). Moreover, it investigates also the relationship between absorbent type and its circulation rate with HCs losses from glycol regenerator tower.*

## 1. 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. In fact, Natural gas that is transported by gas pipelines or processed should meet certain soft specifications, i.e. , for example, $H_2S$ must be reduced to less than 4ppm [1]. Indeed, dome is the northern most domes of the Kirkuk oil fields structure in Iraq [ 2 ]. However, the Dome has not been developed until 2003. In fact, associated natural gas is currently flared at the field. There is a plan to recover and trade this gas to use it either as feedstock to power stations or to sell it in the global market. However, the laboratory analysis has showed that the natural gas has huge quantities of $H_2S$ about (5.3%) and $CO_2$ about (4.4%) [3]. Sweetening process has been done in previous study by using Aspen Hysys [5]. However, sweet gas still wet and contain considerable amounts of water vapor which it may lead to several technical problems such as, hydrates formation and corrosion. Indeed, water vapor in natural gas should be reduced or removed and the main reasons for removing the water from natural could be summarized as follows: water content of natural gas decreases its heat value, liquid water in natural gas pipelines potentially causes slugging in flow conditions resulting in lower flow efficiency inside the pipelines [4, 5]. In most commercial hydrocarbon processes, the presence of water may cause undesirable reactions, such as foaming or catalyst deactivation. Therefore, to prevent such problems, natural gas treating is unavoidable. Therefore, there are different methods for water treating of natural gas such as adsorption, absorption, membrane process, methanol process and refrigeration [7]. Among mentioned methods, absorption which is called dehydration and uses liquid solvent as an absorbent. This method is mostly common technique for treating the natural gas [6], [7] . Indeed, gas dehydration by glycol is capable to reduce the water content in natural gas stream to less than 0.1ppm [8].

## 2. GLYCOL GAS DEHYDRATION PROCESS DESCRIPTION

Glycol process is considered the most successful and common process in gas industry field [6]. Indeed, this process utilizes glycol liquid desiccant as a chemical solvent to remove water vapor from natural gas stream. Moreover, glycol liquid has high affinity towards water vapor. There are several types of glycol that are used in glycol dehydration process. For example, monoethylene glycol (MEG) and diethylene glycol (DEG) [6]. 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 enters to the absorption column at the top side while the rich solvent is collected at the bottom of the column to be sent to the regenerator [9]. Wet gas enters to the absorption column after passing through inlet scrubber. The scrubber removes free liquid and the other liquid droplets in the gas. Both water and hydrocarbons liquid removed in the scrubber decrease the amount of water that has to be removed in the absorption column. This action in its turn decreases also the size of the column and decreases accordingly the amount of TEG needed in dehydration process [8, 9]. Heat exchanger is used for cooling of wet gas before entering to scrubber. Rich TEG passes through a coil, which is used as reflux at the top of the absorption column; to increase its temperature. Also, a three phase flash tank is used for the removal of absorbed acidic gases and hydrocarbons in TEG before entering the rich solvent to the regenerator. The regenerator is considered here as a distillation column, that is separating both the TEG and water content. Indeed, rich TEG is preheated in another heat exchanger before it is fed to the regeneration section. At the end of this process, the regenerated TEG will be cooled in the third step of heat exchanger and will go back to the dehydration column for reuse [10].

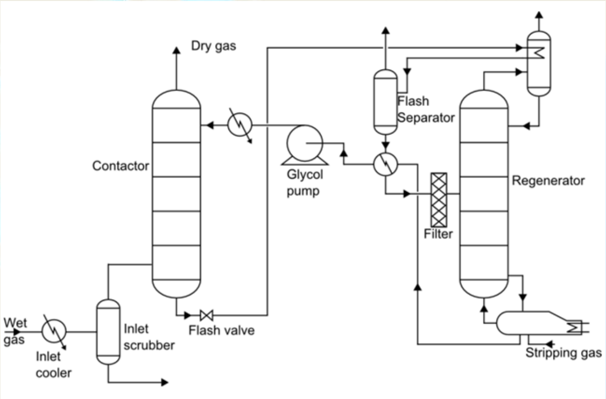


**Figure 1 Typical natural gas dehydration process**

## 3. STEADY SATE SIMULATION AND OPTIMIZATION

Table 1 shows wet gas stream composition and the operating conditions [3]. The expected 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 that are the same data of this case study. Moreover, Hysys fluid package should be carefully chosen which it should be (Glycol Package) as shown in Fig. 2.

**Table 1 Raw natural gas compositions and the operating conditions**

| Components | Mole % |
|---|---|
| Methane | 63.2657 |
| Ethane | 13.8815 |
| Propane | 6.0219 |
| i-Butane | 1.3581 |
| n-Butane | 2.4367 |
| i-Pentane | 1.0286 |
| n-Pentane | 0.7290 |
| n-Hexane | 1.1884 |
| Water | 0.1329 |
| Carbon dioxide | 4.4740 |
| Nitrogen | 0.1098 |
| Hydrogen sulfide | 5.3728 |

**Table 2 Raw natural gas operating conditions**

| Operating conditions | |
|---|---|
| Pressure | 7000 kPa |
| Temperature | 38 °C |
| Flow rate | 102 MMSCFD |

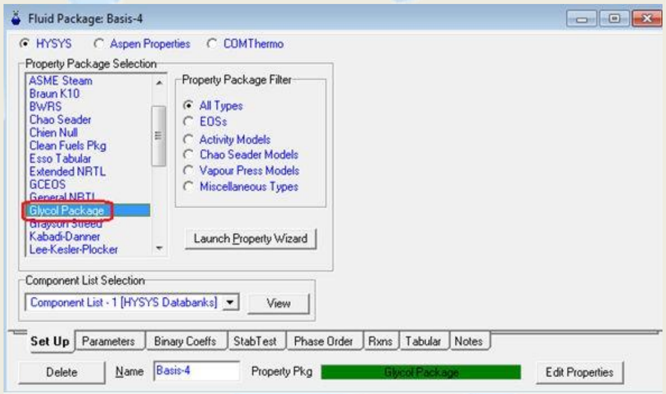


**Figure 2 Hysys fluid package menu**

After achieving above, the simulation environment starts. Moreover, simulation environment is considered the main simulation area. It deals with the plant and considers the flat panel display (FPD) for the process. It is very important to use inlet gas separator to remove any undesirable impurities such as solid particles and liquids. Glycol contactor tower is also a significant part of the plant. It needs some specifications for carrying out its efficient performance such as streams temperature and pressure and the TEG concentration (99% is used). Fig.3 shows Glycol contactor menu. Moreover, rich glycol needs to be regenerated and that be achieved by installing the glycol regenerator. Fig. 4 shows glycol regenerator menu.

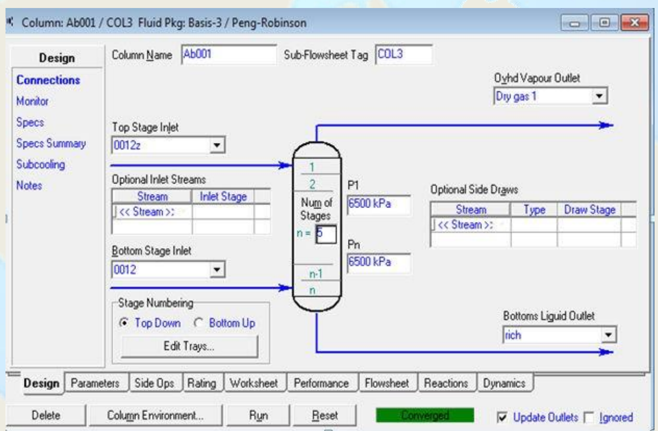


**Figure 3 Glycol contactor menu**

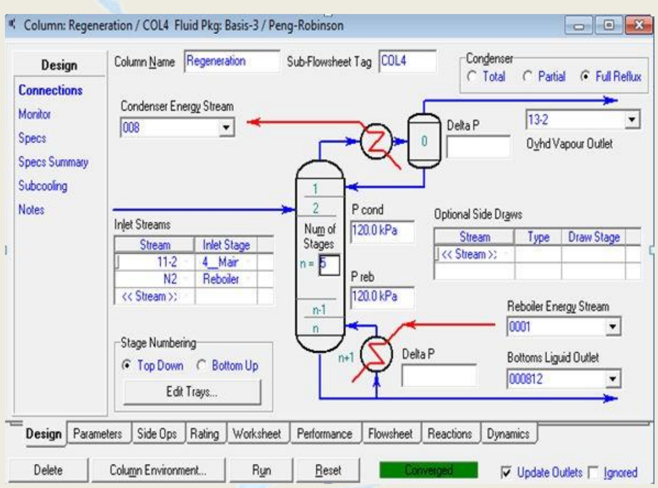


**Figure 4 Glycol regenerator menu**

The simulation process is carried out successfully and Fig. 5 shows process flow diagram of raw natural gas moisture removal plant (dehydration plant). As it seems from Fig. 5, several process units are used in glycol process. In fact, 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. In fact, glycol concentration may be built up in the process because of water and amine losses with dry gas. Therefore, water make up stream will maintain and support the concentration of TEG at acceptable value. The simulation process done and the process achieved highly succeeded to fulfill a noticeable rate of water removal from the natural gas stream. That will be discussed in results and discussion part. To make up the lost TEG in process cycle, it is necessary to admit the gas stream flowing from the contactor, separator and regenerator to a component splitter. In the component splitter the TEG is separated from the gas, creating a side stream of pure TEG that is transferred back to the TEG main stream. A mixer is required to mix the recovered TEG with the basic TEG from the regenerator. Fig. 6 shows splitter element menu.

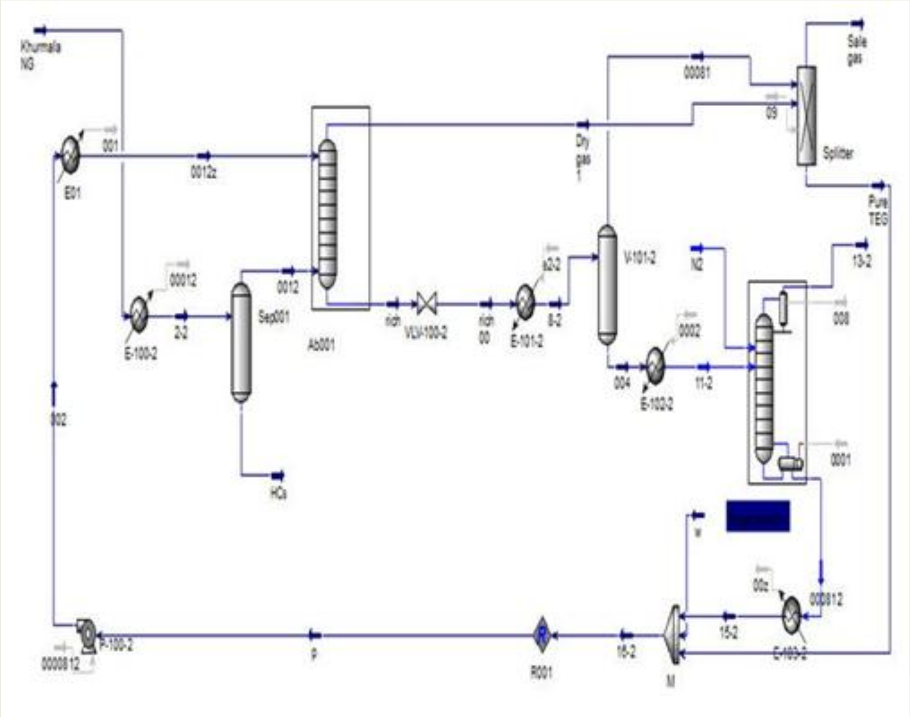


**Figure 5 Process flow diagram of raw natural gas moisture removal plant**

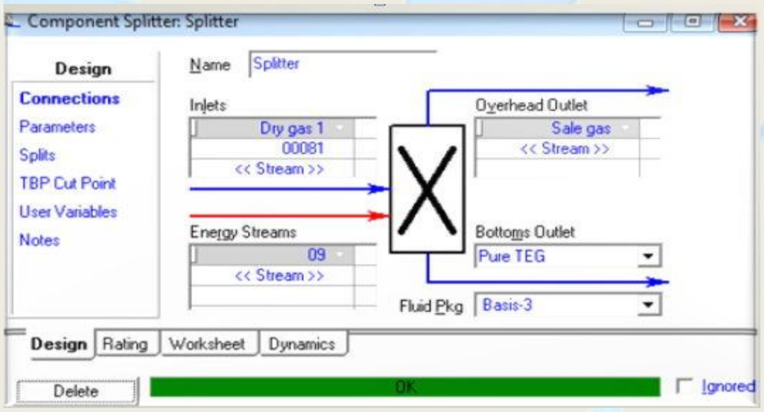


**Figure 6 Glycol splitter menu**

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. 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 purity 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 [11]. 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 is to examine several specific operating conditions such as absorbents circulation rate on the process efficiency.

## 4. RESULTS AND DISCUSSION

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

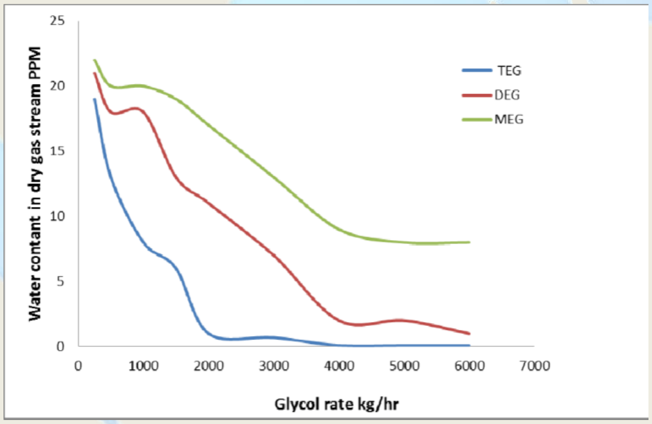


**Figure 7 Water content in the dehydrated gas for the different absorbents**

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

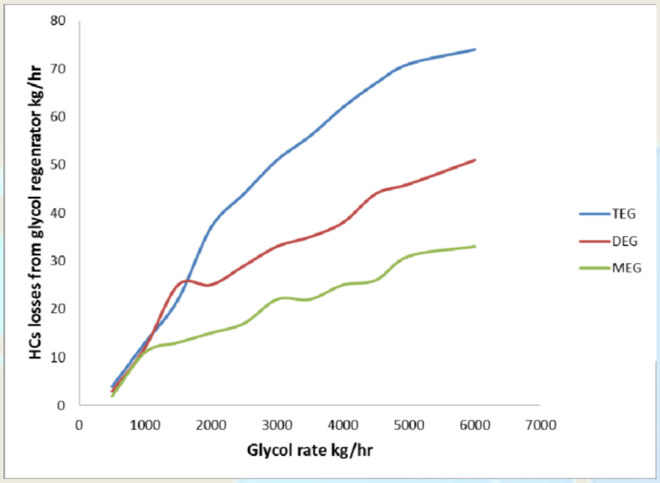


**Figure 8 Relationship between HCs and Glycol rate**

From Fig. 7 it can be seen that TEG absorbs a lot of more HCs than DEG and leads to more HCs losses from glycol regenerator as its circulation rate increases. Also, it can be seen from the above figure (Fig. 7) that increasing absorbent circulation rate for all glycol types results in high HCs losses from glycol regenerator tower. However, use the MEG poses lowest HCs losses at most circulation rate while use the DEG has moderate HCs losses.

## 5. CONCLUSION

In conclusion, this study achieved raw natural gas dehydration process simulation and optimization by using Aspen HYSYS. It can be argued that wet gas contains some quantities of water vapor that may lead to severe technical problems such as hydrates formation and pipeline corrosion. However, these problems could be solved by installing gas dehydration unit for gas plant. Moreover, simulation work achieved high water removal. It could be argued that use the TEG glycol at 4000kg/hr circulation rate can achieve good gas removal. However, use the TEG poses high HCs losses for glycol generator at the mentioned circulation rate. Therefore, reducing TEG circulation rate or use the DEG at 3500kg/hr fulfills also an acceptable water removal result and low HCs losses rate. However, the most appropriate selection may be taken by both the process designers and the process operators.

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