Proceedings of the 3rd International Conference on Chemical Engineering (ICCE2021), Mehran University of Engineering and Technology, Jamshoro, September 22-23, 2021, 60-69

Analysis of solvent's effects on gas dehydration of Hassan Gas field using Aspen HYSYS

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ABSTRACT

Extracted fluids from the reservoirs generally are saturated with water. Presence of water in the fluids that are extracted generates lots of problems for process piping and instruments. In order to save the instruments and environment to meet with dangerous conditions, water content should be under 6-7Ib/MMSCFD. Against this backdrop, Gas dehydration is commonly and widely standardized process of eliminating the moisture proportion out of natural gas and gaseous mixtures. It often precedes either a process pipeline transportation of natural gas or a low temperature-based gas processing system. Importantly, dew content level in natural gas must be reduced to below a certain standard point in order to avoid the hydrate formation as its formation is dangerous when dealing with flow of natural gas in pipeline. In the recent times natural gas is paramount fuel in our life and one of the principal sources of energy for many of our day-to- day needs and activities. There are three major methods of dehydration are: absorption, direct cooling and adsorption. The similar nature persists over the years in Hassan Gas field. In order to meet the requirements for a clean, dry, wholly gaseous fuel suitable for trans-mission through pipelines and distribution for burning by end users, the gas must go through several stages of processing, including the removal of entrained liquids from the gas, followed by drying to reduce water content. In this work, the effects of TEG and MEG solvents on gas dehydration were analyzed using Aspen HYSYS. Hence, the mole percent of natural gas using TEG was 0.75 compared with 0.62 of MEG. Resultantly, it was established that TEG solvent was more effective than the latter in producing anhydrous natural gas at Hassan Gas field.

Keywords:

Natural gas
Dehydration
Tray Colum
Packed Column
Aspen HYSYS

1. Introduction

The demand of natural gas worldwide has been increasing in recent period of time. As 20 percent of energy requirement is filled up by natural gas. It also plays major role in the economic development of world. However, it is extracted in impure state from underground reservoirs. Therefore, it contains numerous non-hydrocarbon compounds for example carbon dioxide, nitrogen and water vapors. Infect, natural gas transported by pipeline must meet certain standards and specifications for example, H_2S must be reduced by 4ppm [1]. In most industrial hydrocarbon processes, the presence of water may result dangerous phenomena and can cause side reactions, foaming or catalyst deactivation, corrosion, and erosion in pipelines. Therefore, in order to prevent such problems, natural gas treating is unavoidable for smooth operation of processes. There are different methods for water treating of natural gas for instance, absorption, adsorption, membrane process, methanol process and refrigeration. These methods are used as per water concentration in the raw natural gas [2]. Among mentioned methods, absorption, which is commonly known as dehydration and use liquid solvents such as TEG and MEG as an absorbent, is mostly common technique for treating of natural gas [3]. Dehydration is the removal of water content from the raw natural gas before its transportation in the pipelines. Absorption is the transfer of a component from the gas phase to the liquid phase and is more favorable and efficient method at a lower temperature and higher pressure. Water vapor is removed from the gas by constant intimate contact with a hygroscopic liquid desiccant in absorption dehydration unit. This contact is usually achieved in packed or trayed towers. Glycols have been widely used as effective liquid desiccants for the absorption of water. Moreover, TEG has gained nearly universal acceptance as the most cost effective of the glycols due to its superior dew point depression, operating cost, and operation reliability for the process.[4]. Indeed, gas dehydration with glycol solvent is capable to reduce the water content of natural gas less than 0.1ppm [5].

In this research, the solvents effect will be investigated by varying different parameters and the comparative analysis will also be discussed.

2. Basis glycol gas dehydration process description

Glycol process for treating natural gas is regarded the most common, successful, and efficient method in gas industry. Indeed, this process utilize glycol liquid desiccant as a chemical solvent to make water vapor free natural gas stream. Moreover, glycol solvent has high affinity towards water vapor and there are numerous types of glycols that are utilized in glycol dehydration process for example, monoethylene glycol (MEG), diethylene glycol (DEG) and triethylene glycol (TEG) [6]. Dehydration process consists of different operation units for instance, contactor tower, regenerator tower and heat exchanger. Fig. 01 indicates gas dehydration process. During the process, the lean glycol such as DEG enter to the top of absorption column or contact column and the rich solvent is collected at the bottom of column and it is sent to the regenerator [7]. The wet gas enters to the bottom of absorption column after passed through the inlet scrubber. The scrubber removes free 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. The Heat exchanger uses for the cooling of wet gas before enters to scrubber. Rich TEG passes through a coil, which is used as a reflux at the top of the absorption column, to increase its temperature. A three-phase flask tank uses for removal of absorbed acidic gases and hydrocarbon in TEG before rich solvent enter to the regenerator, which is distillation column and separate the TEG and water content. Indeed, rich TEG is preheated in anther heat exchanger before it feed to the regeneration section of the process. At the end of the overall process cycle, the regenerated TEG will cool in the third step of heat exchanger and will back to the dehydration column for reuse [8].

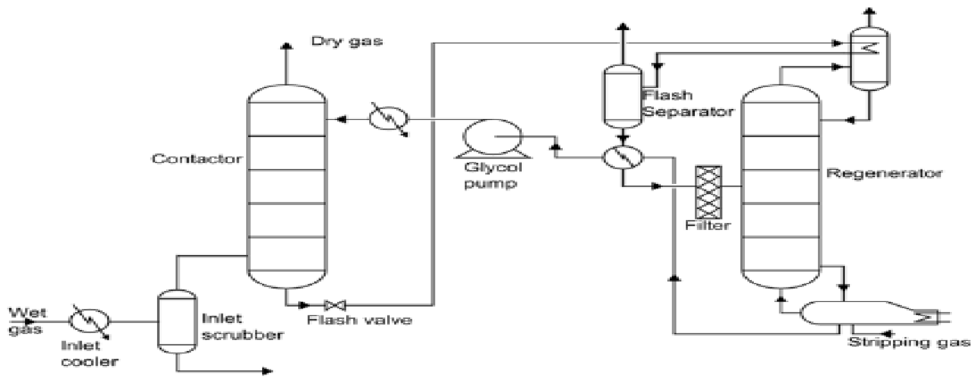

Fig. 01: Typical Gas dehydration process

3. Methodology

The simulation of a system is the operation of a model, which is a representation of that system. This study in simulation was conducted to find the effects of solvent on natural gas dehydration. Moreover, this research study utilized the Aspen HYSYS®10. This work was segregated in two parts. In the first part, the necessary data was collected and in the second process was of model development

3.1. Data collection

Data collection is the prerequisite for the simulation run. The model development and simulation of natural gas dehydration process required the following input data.

- Natural gas flow rate and its composition (Table 01)
- Inlet Gas pressure (Table 02)
- Inlet gas temperature (Table 02)

3.2. Composition of natural gas and its parametric range

Natural gas is not extracted in pure from the underground earth. It is mixture of various components when it is found in impure state. The composition of natural gas varies from area to are as it is mixture of numerous components. But when it is extracted, it is found in impure state and that impure compounds must be removed in order to prevent the creation of dangerous conditions that can harm the overall process. The composition of natural gas and the parametric range is defined in table 01 and 02.

Table 01: Natural gas composition.

Components	Mole Fraction
Methane	0.8053
Ethane	0.0152
Propane	0.0038
i-butane	0.0009
n-butane	0.0013
i-pentane	0.0005
n-pentane	0.003
n-hexane	0.0012
Nitrogen	0.13
Carbon Dioxide	0.0175
Water content	0.0240
TEG	0.000

Table 02: Feed gas parameters

Parameters	Values
Molar flow rate of gas (MMSCFD)	14
Feed gas temperature (f)	120
Gas inlet pressure (Psig)	825

3.2. Process modeling

The process modeling is made up of various stages. It requires component selection, its composition, parametric range, and fluid package. The modeling methodology is discussed below in detail.

Components selection

In the first step for modeling and simulation environment of natural gas dehydration, the components are selected as per the feed composition of gas.

Simulation environment

After selection of components there is a step for simulation and modeling of the process. For this, simulation environment, which is a screen for entertaining the modeling of process (fig. 02).

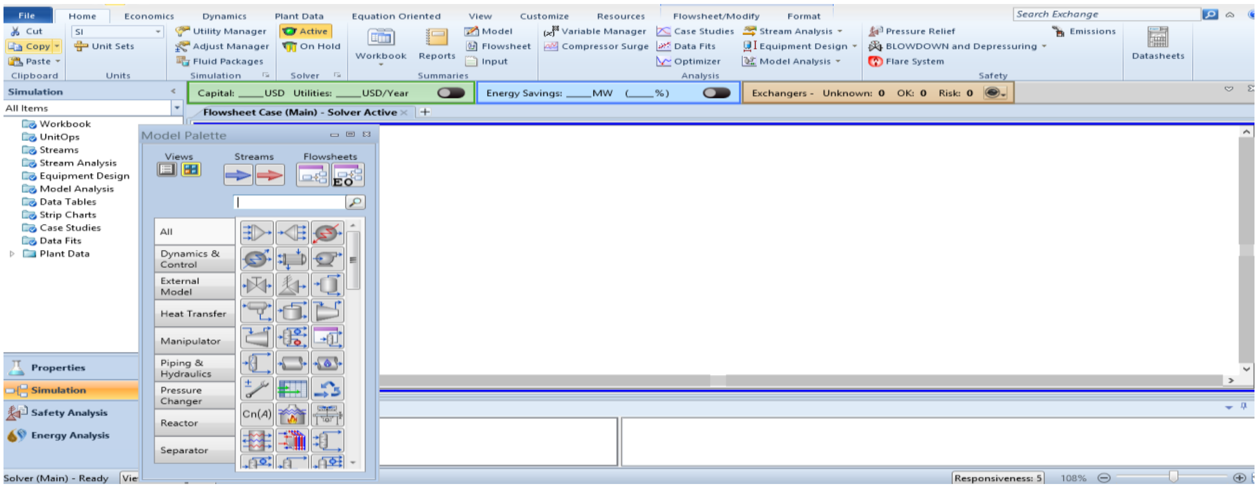

Fig. 02: Simulation environment

Development of model in Aspen HYSYS®10

In this work a model of natural gas dehydration system (Fig. 03) was developed by using Aspen HYSYS version 10. The PR (Peng-Robinson) equation of the state as described by the equation (1) was solved to calculate the specific volume of a gaseous mixture of chemical at a specified temperature and pressure. Moreover, the specific process conditions mentioned in table 01 and table 02 were maintained for fully conversion and accurate analysis of results.

$$P = \frac{RT}{v - b} - \frac{a}{v(v + b) + b(v - b)} \qquad (1)$$

Where P is Pressure, T is Temperature, R is General gas constant, $\hat{v}$ is Specific volume and Z is Compressibility factor of real gas.

4. Results and discussion

Hasan gas field dehydration unit was simulated by using Aspen HYSYS simulator and TEG is adopted firstly as absorbent liquid and the comparison of Tray column and bubble column was carried out. It is achieved that TEG with bubble column showed good dehydration ability. Moreover, the result and discussion section portray complete image of natural gas dehydration by varying flowrate of solvents and the inlet gas stream, and the impacts of parametric change activity will be analyzed in this section.

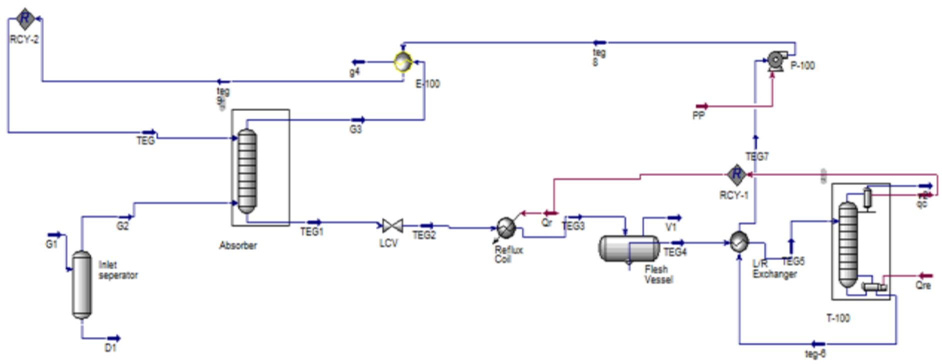

Fig. 03: Simulated Natural gas dehydration unit

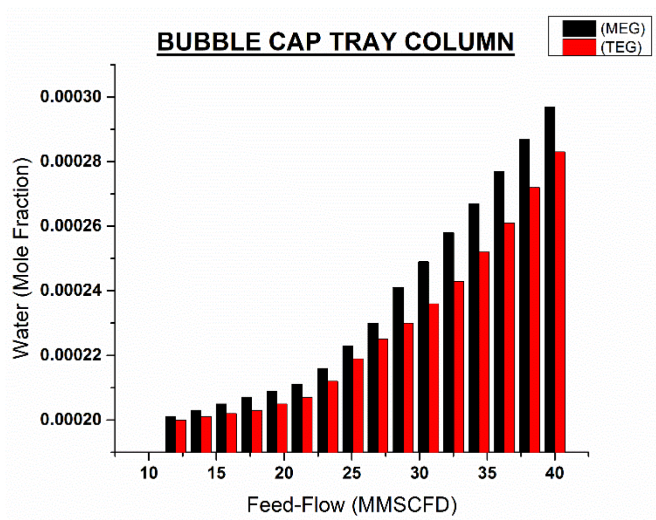

Fig. 04: Effects of feed flow rate w.r.t Water in purified gas stream

Fig. 04 describe the effects of increasing feed flow rate w.r.t water mole fraction in dry gas at the outlet of absorber at constant flow rate of solvents (MEG and TEG). It can be seen that at constant flow rate of absorbent with increasing inlet gas stream flow rate the mole fraction of water constantly increasing. However, the TEG solvent gives less mole fraction of water vapor in outlet gas stream for the same flow rate of gas as compared to MEG.

Simulation results are compared with published experimental measurements in fig. 05. It can be seen that literature and simulation results that the comparison of the literature and real simulated data shows very negligible difference in values for the same minimum flow rate of gas at 20 MMSCFD and maximum flow rate of 80MMSCFD.

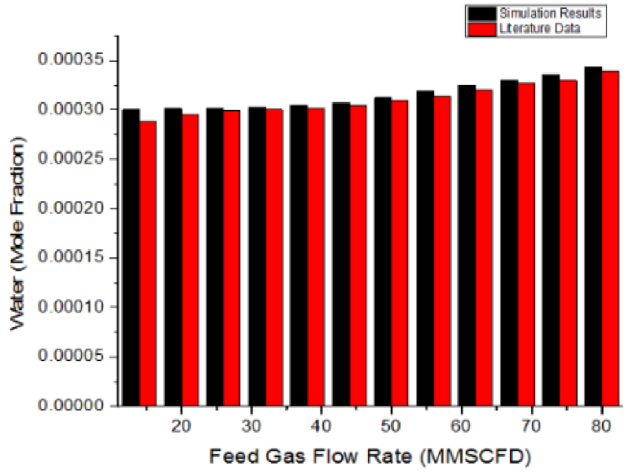

Fig. 05: comparison of simulation and literature results with feed gas flow rate and water vapor in dry gas

When the gas feed flow rate is increasing at the constant solvent flow rate, the water vapor in dry gas is increasing because at the constant flow rate of solvent and increasing inlet flow of the gas feed the absorbing capacity of solvent is decreasing and gives indirect comparison.

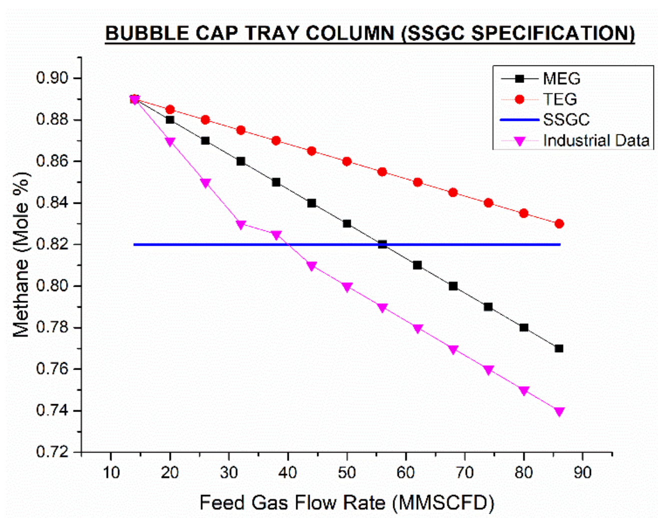

Fig. 06: Relation of gas flow rate at constant solvent slow with methane mole fraction.

Fig. 06 depicts light on the constant solvent flow rate and methane mole percent in the outlet stream. Moreover, the bottom line of 82% of methane mole fraction was set for the analysis. Therefore, pattern of fig. 06 indicates that the specified SSGC methane mole % in natural gas (82%) When TEG @ 90 MMSCFD MEG@ 55 MMSCF Industrial data @ 45 MMSCF. It shows that the margin of around 40 MMCFD with simulation results. Thus, this margin flow of 40MMSCFD can be utilized for the greater efficiency and overall improvement of the process.

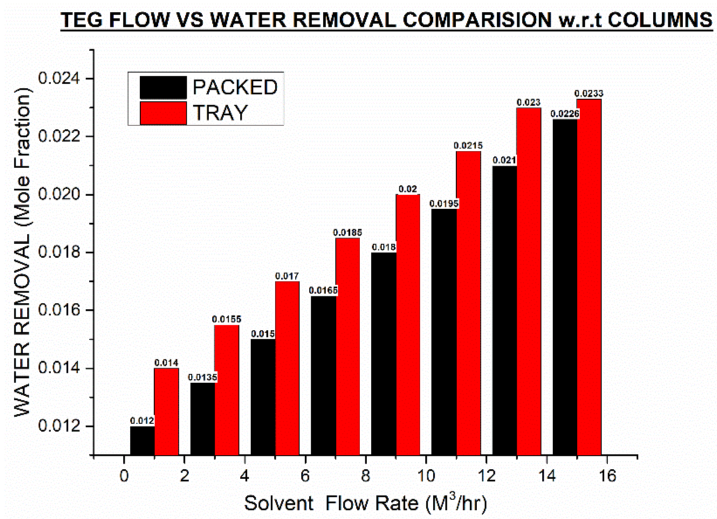

Fig. 07: Solvent flow vs water mole fraction for tray and packed column.

Similarly, the simulation was carried out to investigate the effects of increasing solvent flow rate with water removal mole fraction. The increasing solvent flow rate resulted increasing water removal percentage (Fig. 07). At the same flow rate of 16m^3/hr of solvent the bubble tray column gave more feasible and efficient results and compared the packed column.

Moreover, for the further manifestation of the results and the relation of feed gas flow rate and the methane mole percent was also observed which is clearly represented and shown in fig. 08, that is mentioned above. It can be observed that with the continuously Increasing inlet feed flow rate of gas at constant solvent flow rate results in decreasing methane mole % in product stream. However, it is also observed that methane mole percent is decreasing in the outlet stream but methane percent decreasing at the lower rate when TEG is utilized as the solvent as compared to the MEG when utilized as the solvent. Thus, it is observed that TEG is better solvent and gives suitable and most efficient outcomes as compared to MEG and all other solvents utilized for the removal of water content from the raw natural gas in order to purify it to make it efficient. Thus, the relation gives very clear outcomes when we purify the gas stream in the processing plants.

In fig. 09 depicts the effect on of solvent flow on heat required by the reboiler. It was observed that increase in the Solvent flow rate directly proportional to heat required by the reboiler because the greater the contact of solvent with water vapor will require high reboiler duty.

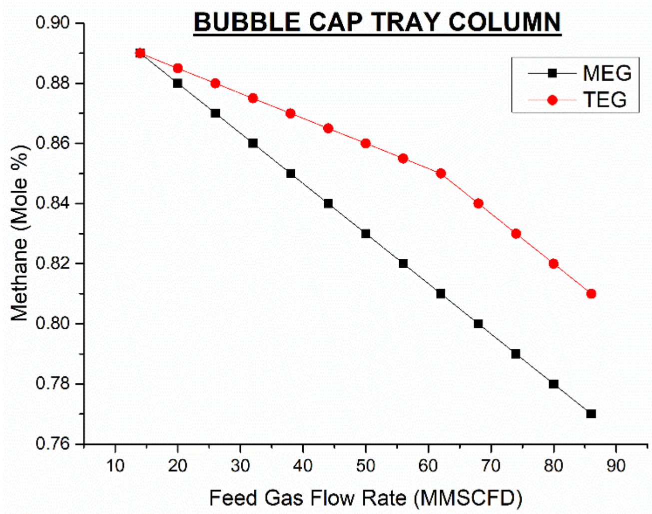

Fig. 08: Effect of feed gas flow on methane mole percent

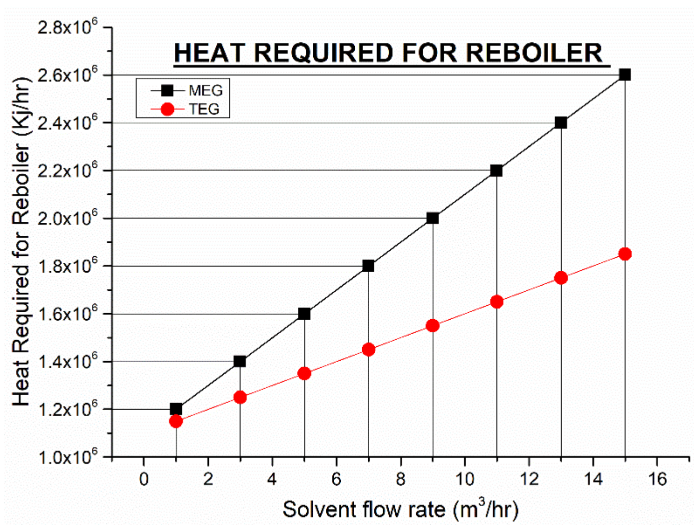

Fig. 09: Effect of solvent flow rate on reboiler heat requirement

Moreover, it was observed that TEG will require less reboiler duty as compared to the MEG because the TEG is more efficient solvent and it require less amount of regeneration and reboiler duty.

5. Conclusion

Natural gas dehydration unit is designed to remove water vapor from raw gas to make natural gas anhydrous in order to meet pipeline specification of water content in the processed gas stream. By using Aspen HYSYS version 10, Natural gas dehydration unit was designed, process conditions and composition were inputted and simulated. The results obtained showed water content from natural gas stream from reservoir can be reduced to the standard pipeline specification by using

TEG. However different water content in the processed gas stream were obtained from different flow rates of TEG. The result obtained through simulation study showed the increasing flow rate of solvent for a specific flow of inlet gas results decrease in water vapor in outlet gas stream. Moreover, the constant flow rate of solvent with increasing gas stream flow rate results in constant increase in mole fraction of water vapor in outlet gas stream. Furthermore, this work indicates that the specified SSGC methane mole % in natural gas (82%) can be achieved When TEG @ 60 MMSCFD MEG@ 42 MMSCF Industrial data @ 40 MMSCF. In comparison to both columns and literature, it shows that the margin of around 40 MMCFD of gas feed in packed column and 45 MMSCFD in tray column is obtained. Therefore, marginalized results of simulation can be utilized for the economy of the process and overall reduction of extra costs in the operation of dehydration unit.

Acknowledgment

Authors would like to extend his gratitude to Chemical Engineering Department Mehran University of engineering and technology, Jamshoro for their consistent support and engagements.

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