# SIMULATION OF NATURAL GAS SWEETING PROCESS USING MONOETHANOLAMINE (MEA)

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**Abstract:**

The process of remove acid component for natural gas is called gas sweeting, this is attained by absorbing them with basic solution such as alkanolamines, through a reversible exothermic reaction that subsequently allow for their regeneration. In this theoretical investigation, the absorption of $CO_2$ and $H_2S$ present in natural gas using the ASPEN HYSYS V.14 process simulator with chemical solvent package for amines, using an aqueous monoethanolamine solution (MEA) as an absorber. The ASPEN HYSYS is a good tool for calculating process operating variables. Thus, fitting results were obtained absorption when the flow rate and concentration of amine are increased. The process absorption proceeds best at low temperature and high pressure; conversely, the desorption process improves at high temperatures and low pressure.

Keywords: sweeting process, natural gas, MEA, simulation

# محاكاة تحلية الغاز الطبيعي باستخدام أحادي إيثانول أمين (MEA )

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**المستخلص:**

تُسمى عملية إزالة المكونات الحمضية من الغاز الطبيعي "تحلية الغاز"، ويتم ذلك بامتصاصها بمحلول قاعدي مثل الألكانولامينات، من خلال تفاعل طارد للحرارة عكسي يسمح بتجديدها. في هذا البحث النظري، تم امتصاص ثاني أكسيد الكربون وكبريتيد الهيدروجين الموجودين في الغاز الطبيعي باستخدام مُحاكي عملية ASPEN HYSYS V.14 مع حزمة مذيبات كيميائية للأمينات، باستخدام محلول أحادي إيثانول أمين مائي (MEA) كممتص. يُعد ASPEN HYSYS أداة جيدة لحساب متغيرات تشغيل العملية. يكون امتصاص العملية أفضل عند درجات حرارة منخفضة وضغط مرتفع؛ في المقابل، تتحسن عملية الامتزاز عند درجات حرارة وضغط مرتفعين.

**الكلمات المفتاحية:** عملية التحلية، الغاز الطبيعي، MEA، المحاكاة.

## Introduction:

The demand for natural gas has significantly increased in recent decades, playing a crucial role in the global economy and development. However, natural gas often contains various impurities, such as acid gases, which must be removed to meet pipeline specifications. According to regulations limit H2S content to approximately 4 ppm and CO2 to about 2% in natural gas streams. Natural gas is a fossil fuel derived from oil deposits. It contains methane, ethane and other hydrocarbons. It also contains contaminants such as nitrogen, water, $CO_2$, $H_2S$ [2]. The content $CO_2$ and $H_2S$ in natural gas converts it you in a bitter ga. These substances are undesirable since if the $H_2S$ is present in natural gas then it causes a corrosion to pipe, turbines, compressors and other equipments.[3], also, H2S is a toxic and poisonous chemical substance, and if exposed to the environment through leakage, it causes harm to humans and animals in the surrounding area. On the other hand, natural gas with a high $CO_2$ content it reduces its calorific value and is also responsible for corrosion problems since it forms carbonic acid when it reacts with water vapor. Once this substance ($CO_2$+$H_2S$) the gas is called sour gas. The marketing of natural gas is restricted the $H_2S$ less than 4 ppm and CO2 less than 2%. Because of this, it is necessary to perform a sweeting treatment so that the natural gas meets specification and can be transported. Natural gas sweeting processes arise with the objective of removing theses acid gases from the gas stream. Gas sweeting by amine s considered the most popular process among natural gas sweeting methods, in fact, the natural gas sweeting process by amine has several advantages, it a continuous process and with the capacity to regenerate the solvent. The purpose of this work is it to simulate the natural gas sweeting process using

monoethanolamine (MEA), MEA is a primary amine with the chemical formula $HOCH_2CH_2NH_2$, a colored liquid clear, transparent and hygroscopic with a slight ammoniacal odor; it is the strongest, most reactive and simplest base of all the amines, its molecular weight considered as small allows greater transport capacity of acid gases which means lower MEA circulation rate. However, values higher than 15% lead to high corrosion of the system and foam formation [4]. The ASPEN HYSYS computational tool was used for the simulation.

Hernán and Natalia, in this research was carried out the absorption of CO2 and H2S extent in the natural gas used in the ASPEN PLUS process simulator with its thermodynamic package for amins, using as an absorb an aqueous solution of monoethanolamine (MEA), at the end in the research, was obtained sweet gas with required specifications.[4]

## II. Material and methods

### A) Description of the gas sweeting process natural using monoethanolamine.

The sweeting process is carried out in a system composed of an absorber tower and a regenerator tower. The first unit is where the acid gas is absorbed, that is, where the sweet or treated gas is obtained. The second unit is necessary to recover and recondition the amine. The sour gas enters the absorption column through the bottom, and the lean amine aqueous solutions enters though the top, and both streams come into contact, resulting in the absorption of acid gases. The sweet or clean gas exits through the top of the column, and a liquid called rich amine exits through the bottom of the column. This rich amine contains the absorbed acid gas ($CO_2$+$H_2S$). to separate $CO_2$ and $H_2S$ of the rich amine, this

mixture is passed to a regenerating column, where the acid gas is separated at the top and the lean amine at the bottom. Figure 1 shows the basic flow diagram of a natural gas sweeting unit using amine

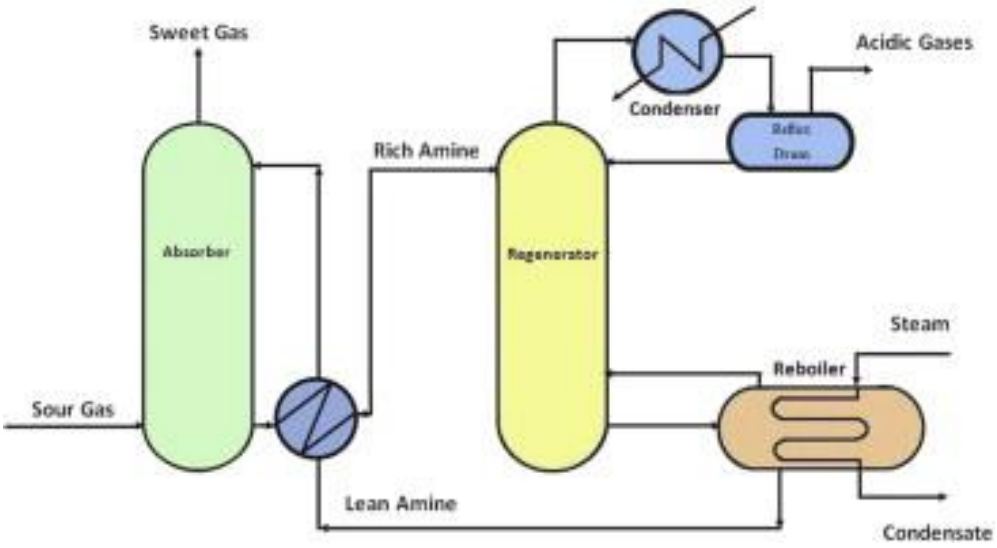



Figure 1 General flow diagram for gas sweeting process by amine solution

b) The natural gas composition and operating conditions are shown in Table 1 and Table 2 respectively.

Table 1 natural gas composition

| Component | Mole % |
|---|---|
| Methane | 70.87 |
| Ethane | 12.98 |
| Propane | 7.4 |
| i-Butane | 1.2 |
| n-Butane | 2.28 |
| i-Pentane | 0. 65 |
| n-Pentane | 0. 43 |
| n-Hexane | 0. 72 |

| Component | Mole % |
|---|---|
| Nitrogen | 1.2 |
| $CO_2$ | 1.67 |
| $H_2S$ | 0.4 |
| $H_2O$ | 0.2 |

Table 2 The conditions of sour gas and absorbent flow

| | Temperature, °C | Pressure, bar-g | Molar flow |
|---|---|---|---|
| Sour gas | 37.5 | 44.75 | 3.0 MMscfd |
| absorbent | 41.09 | 42.75 | 1100 bbl/d |

**Simulation:**

Fig 2 shows flow diagram for the natural gas sweeting process plant installation of a flash tank for rich amine may be very useful in order to avoid any technical problems that might be caused by rich amine impurities. Besides, the ADJUST function is also important to adjust the mass flow rate of lean amine with the H2S molar function in sweet gas stream.[1] In gas sweeting makeup refer to adding fresh amine solution to the system to replenish losses due to evaporation, reactions, or other factors. This ensures the amine solution maintains its desired concentration and ability to absorb acid gases like $H_2S$ and $CO_2$. The simulation process is done and process achieved high acid gas removal which will be discussed in results and discussions

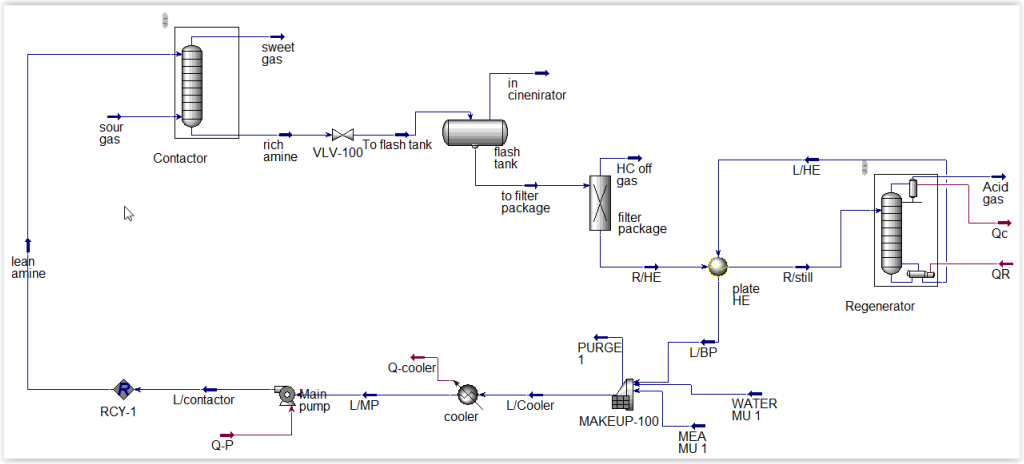



Figure 2 Aspen hysys simulation of natural gas sweeting plant

## Result and Disscusion:

Table 3 shows the results by stream of the steady state material and energy balance.

Table 3 material and energy balance for natural gas sweeting plant

| | Sour gas | Lean amine | Sweet gas | Rich amine | Acid gas | L/HE |
|---|---|---|---|---|---|---|
| Vapor fraction | 1 | 0 | 1 | 0 | 1 | 0 |
| Temperature, °C | 37.78 | 40.65 | 40.70 | 48.92 | 44.99 | 122.9 |
| Pressure, bar-g | 44.82 | 42.75 | 41.37 | 43.09 | 0.62 | 0.655 |
| Molar flow, MMSCFD | 3.00 | 5.18 | 2.927 | 5.252 | 0.0659 | 5.177 |
| Mass flow, tonne/d | 83.20 | 175.0 | 79.78 | 178.4 | 3.206 | 175.0 |
| volume flow, barrel/d | 1418 | 1096 | 1389 | 1126 | 25.51 | 1096 |

| | Sour gas | Lean amine | Sweet gas | Rich amine | Acid gas | L/HE |
|---|---|---|---|---|---|---|
| Heat flow, KJ/h | -1.298e+007 | -7.335e+007 | -1.188e+007 | -7.445e+007 | -1.038e+006 | -7.121e+007 |
| Component | Molar flow, MMscfd | | | | | |
| Methane | 2.1261 | 0 | 2.1197 | 0.0063 | 0 | 0 |
| Ethane | 0.3894 | 0 | 0.3881 | 0.0016 | 0 | 0 |
| Propane | 0.2220 | 0 | 0.2213 | 0.0005 | 0 | 0 |
| i-Butane | 0.0360 | 0 | 0.0357 | 0.0005 | 0 | 0 |
| n-Butane | 0.0684 | 0 | 0.0682 | 0.0005 | 0 | 0 |
| i-Pentane | 0.0195 | 0 | 0.0193 | 0 | 0 | 0 |
| n-Pentane | 0.0129 | 0 | 0.0129 | 0 | 0 | 0 |
| Hexane | 0.0216 | 0 | 0.0217 | 0 | 0 | 0 |
| Nitrogen | 0.0360 | 0 | 0.0360 | 0 | 0 | 0 |
| $CO_2$ | 0.0501 | 0.0565 | 0 | 0.1066 | 0.0500 | 0.0564 |
| $H_2S$ | 0.0120 | 0.0005 | 0 | 0.0126 | 0.0120 | 0.0005 |
| $H_2O$ | 0.0060 | 3.9244 | 0.0044 | 3.9253 | 0.0039 | 3.9216 |
| MEAmine | 0 | 1.1987 | 0 | 1.1985 | 0 | 1.1985 |

Figure 3 summarizes the most important values from the simulation using the MEA aqueous solution. In the absorber, the $CO_2$ content was reduced from 1.67% to 4.452e-006 % and the $H_2S$ content was reduced to 9.169e-002 ppm trace. This corresponds to a 99.99% recovery of $CO_2$ and a 99.99% recovery of $H_2S$ exiting the bottom of the column with the rich amine.

**Absorption column:**

Table 4 shows the recovery rates of the components at the top and bottom of the column. A change is observed in stream of rich amine from the bottom. This corresponds to a recovery of 99.99% for carbon dioxide and 99.99% for hydrogen sulfide.

**Table 4 shows the recovery rates of the component for absorption column**

| Component | Sweet gas | Rich amine |
|---|---|---|
| Methane | 1 | 0.0012 |
| Ethane | 1 | 0.0003 |
| Propane | 1 | 0.0001 |
| i-Butane | 1 | 0.0001 |
| n-Butane | 1 | 0.0001 |
| i-Pentane | 1 | 0 |
| n-Pentane | 1 | 0 |
| Hexane | 1 | 0 |
| Nitrogen | 1 | 0 |
| $CO_2$ | 4.452e-006 | 0.9999 |
| $H_2S$ | 1.29e-005 | 0.9999 |
| $H_2O$ | 0.0014 | 0.9986 |
| MEAmine | 2.987e-003 | 0.997 |

## Simulation Results:

### Absorber Result

Figure 3 illustrates the temperature variations. As expected, the tower temperature increases from the upper to the lower trays. The reason for the lower temperature variations in the absorption tower is that the amine enters the tower from the top, which significantly affects its temperature.

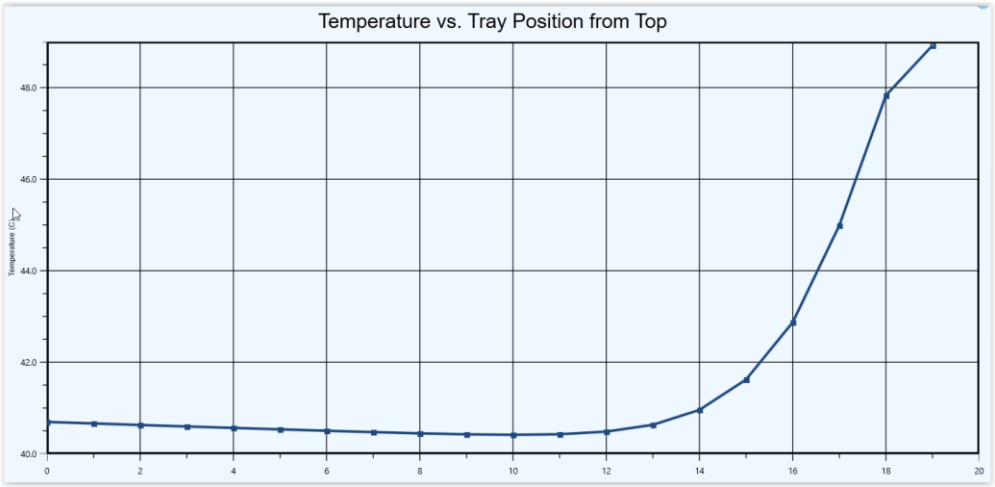
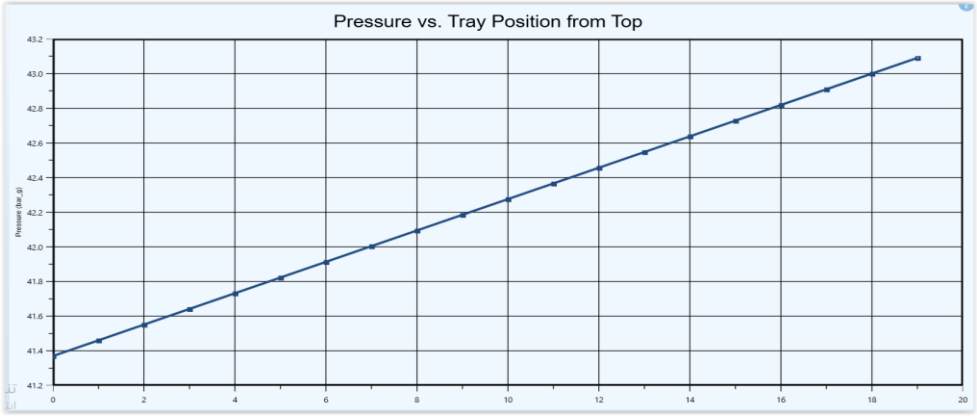
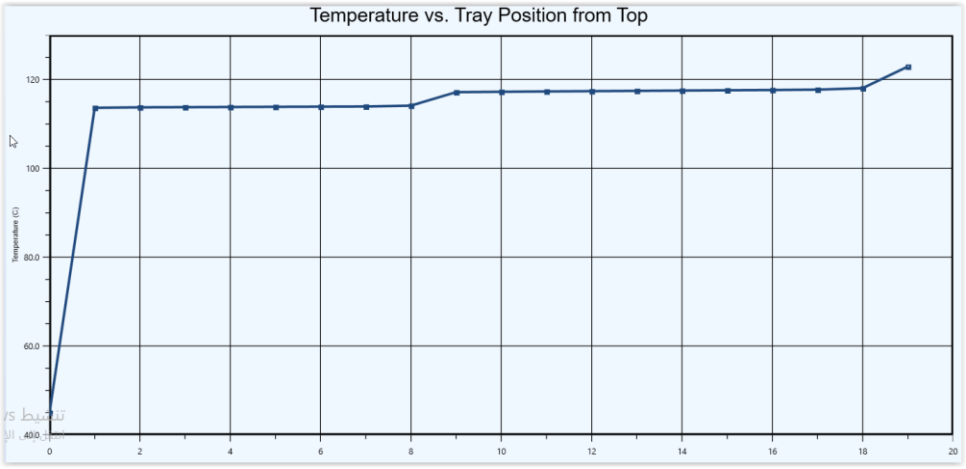



Figure 4 shows the pressure differences, the tower pressure increases from the upper to the lower trays

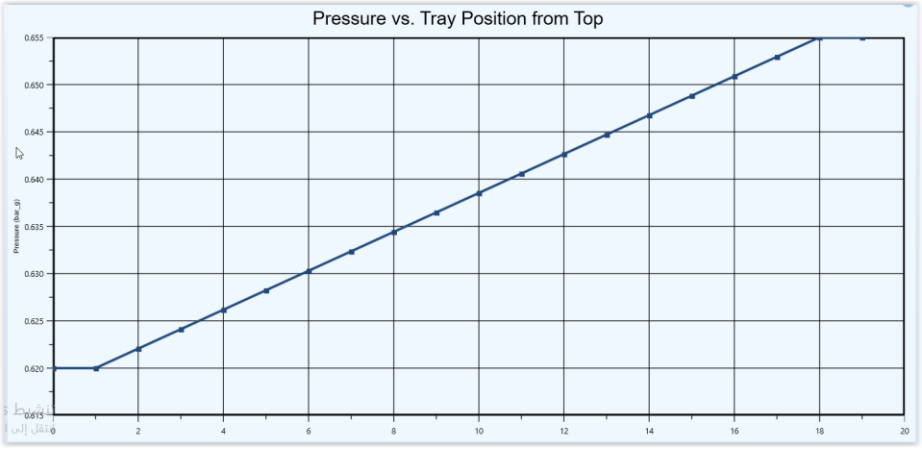



Regenerator results:

Temperature changes in the regenerator Column are illustrated in Figure 3. In the regenerator Column, too many temperature changes are observed in the initial trays, while there are not many temperature changes between 1 to 8 trays then increase temperature from 8 to 9 trays, in contrast, the temperature stabilizes across the trays from 9 to 18, While it increases in trays 19




The figure 5 shows the pressure increase from the 1 tray to the 18 trays. While equals at (0-1) trays and (18 -19) trays.




Lastly, the results related to the reboiler and condenser of the generator column are exposed in Table 5

Table 5 condition of reboiler and condenser in regenerator column

| Parameter | Reboiler | Condenser |
|---|---|---|
| Temperature, C | 122.9 | 44.99 |
| Pressure, bar-g | 0.655 | 0.62 |
| Heat duty, KJ/h | 1.477e+007 | 1.362e+007 |
| Output flow rate, MMscfd | 5.177 | 6.034 |

## Conclusion:

The simulation of H2S and CO2 absorption from natural gas using the primary amine MEA was successfully completed, achieving a satisfactory material and energy balance. This process resulted in a sweet gas that meets the required specifications. Operating at low temperatures helps to prevent amine degradation and avoids corrosion issues.

## References:

1. Abdulrahman, R And Sebastine, I., (2012), Natural Gas Sweeting Process Simulation And Optimization: a Case Study Of The Khurmala In Iraqi Kurdistan Field, UK WIT Transactions On Engineering Sciences, Vol 81, ISSN 1743-3533 (On-Line)
2. Arnold, K Stewart, M., (2011) Gas Sweetening and Processing Field Manual. Waltham: Gulf professional publishing
3. Arnold, K. Stewart, M. (2002), Aspen Technology, Inc. ASPEN PLUS Manual. Physical Property Model, editors.
4. Tixi, H. and Barahona, N. (2019), simulation of natural gas sweeting

process using monoethanolamine aqueous, Issue 22 vol. 2