Simulation Process for Flash Separator of Light Hydrocarbons From Natural Gas by Aspen Hysys Program

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Abstract
In light of this energy crisis, the increasing demand for gas production hampers industrial operations. In general, as natural gas is one of the most important energy sources in the country. Unless other sources of energy are developed as an alternative, natural gas is our only hope. Almost all existing processing plants are now operating beyond capacity. However, the gas industry needs continuous development to meet the growing need for sustainable energy production. Natural gas processing simulation as a model for natural gas for the Al-Wafa field in the southwestern part of Libya as a case study using the Aspen Hysys program, A steady-state simulation of the gas processing plant was conducted based on the design data and physical characteristics of the plant to separate light hydrocarbons and determine their chemical composition in the flash separation process using several models of state equations for the gas phase, which is the main goal of the research. The results were fairly close, as follows: For the gaseous mixture emerging from the top of the flash separator, they are (0.9482), (0.0306), and (0.0002) for methane, ethane, and propane, respectively, at a molar flow rate 88.91 kg mol/hr from a flow of 100 kg mol/hr as feedstock and at a hypothetical value for natural gas entering the station. The research results were based on choosing the Ping-Robinson equation as the best equation of state due to its wide use and high accuracy, among several models of equations of state that were used in this study.
Keywords: Natural Gas, Light hydrocarbon, Natural gas, Aspen Hysys, Simulation.

الملخص
وفي ظل أزمة الطاقة هذه، فإن الطلب المتزايد على إنتاج الغاز يعيق العمليات الصناعية. وبشكل عام يعد الغاز الطبيعي أحد أهم مصادر الطاقة في البلاد. وما لم يتم تطوير مصادر أخرى للطاقة كبديل، فإن الغاز الطبيعي هو أملنا الوحيد. تعمل جميع مصانع المعالجة الحالية تقريبًا الآن بما يفوق طاقتها. ومع ذلك، تحتاج صناعة الغاز إلى التطوير المستمر لتلبية الحاجة المتزايدة لإنتاج الطاقة المستدامة. محاكاة معالجة الغاز

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الطبيعي كنموذج للغاز الطبيعي لحقل الوفاء في الجزء الجنوبي الغربي من ليبيا كدراسة حالة باستخدام برنامج Aspen Hysys، تم إجراء محاكاة الحالة المستقرة لمحطة معالجة الغاز بناءً على بيانات التصميم و الخصائص الفيزيائية لمصنع فصل الهيدروكربونات الخفيفة وتحديد تركيبها الكيميائي في عملية الفصل الوميضي باستخدام عدة نماذج من معادلات الحالة للطور الغازي وهو الهدف الرئيسي للبحث. وكانت النتائج متقاربة إلى حد ما، كما يلي: بالنسبة للخليط الغازي الخارج من أعلى فاصل الفلاش، فهي (0.9482)، (0.0306)، و (0.0002) للميثان والإيثان والبروبان على التوالي عند التدفق المولي. معدل 88.91 كجم مول/ساعة من تدفق 100 كجم مول/ساعة كمادة أولية وقيمة افتراضية للغاز الطبيعي الداخل إلى المحطة. اعتمدت نتائج البحث على اختيار معادلة بينج روبنسون كأفضل معادلة للحالة نظراً لاستخدامها الواسع ودقتها العالية، من بين عدة نماذج للحالة تم استخدامها في هذه الدراسة.

الكلمات المفتاحية: الغاز الطبيعي، الهيدروكربونات الخفيفة، أسبن هايسيس، المحاكاة.

1. Introduction

The nature of the gas is a mixture of hydrocarbon and non-hydrocarbon gases. Non-hydrocarbon gases contain carbon dioxide, hydrogen sulfur, and nitrogen. The properties of natural gas vary depending on the pressure, temperature, and composition of the gas. Gas properties compare gas density, gas pseudo critical pressure and temperature, gas viscosity, gas compressibility factor, gas density, gas formation volume fact, and gas compressibility. The first two depend on the composition. The four last depend on the pressure [1]. These properties are needed in the industrial oil and gas industry to evaluate new gas fields, calculate initial gas reserves, prepare for future gas production, and image production pipes and pipelines [2]. The properties of natural gas play a very important role in gas production. Furthermore, knowledge of oil properties is fundamental [3].To constrain the global use of natural gas, which is growing. This is primarily attributed to its environmental advantages over other fossil fuels such as oil and coal. There is a worldwide drive toward increasing the utilization of natural gas and the need to minimize energy consumption and increase the profit associated with the process. These objectives can be achieved by reducing the time required to get products to market, increasing the quantity and quality of products produced, and designing plants for optimum performance along their life cycle.

In industries, these difficult problems are often not solved by hand for two reasons. The first is human error, and the second is time constrain. Over the past 35 years, there has been significant growth in the contribution of gas to total global primary energy demand [4]. The main use of natural gas (NG) is as fuel; It can also be a source of hydrocarbons used in petrochemical feed stocks [5]. Its clean combustion and ability to meet strict environmental requirements have increased the demand for natural gas [6]. Most of the world's gas reserves are found in offshore fields [7]. Natural gas is gas obtained from natural underground deposits, either as free gas or as gas associated with crude oil. It often consists of large amounts of methane (CH_4) and small amounts of other hydrocarbon compounds. The gas usually contains impurities such as H_2S, N_2, and CO_2. It is also usually saturated with water vapor. The main natural gas market is accessed through transmission lines, which distribute it to various consumption centers, such as industrial, commercial, and domestic [8]. Field processing operations are then carried out to treat the natural gas to meet the requirements and specifications established by the gas transportation companies. The main objective is to have natural gas free of impurities as the main product [9].

2. Problem Statement

We have a stream containing 86.06% methane,9,90% ethane, 1.4% propane, 0.032% i-butane, and 0.028% n-butane at 26°C a flow rate of 100 kgmol/hr, and atmospheric pressure. This flow must be compressed to 169 Kpa, output from compressor and then cooled to -127°C. The resulting vapor and liquid must be separated into two product streams. Required the flows and compositions of these two flows as shown in figure 1.

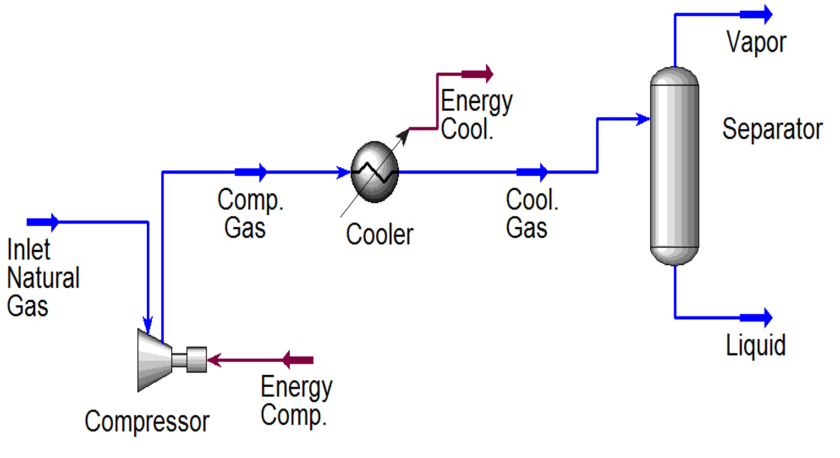

Figure 1. Process Flow Diagram for a Compressing and Flashing Natural gas Unit

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3. Materials and Method

The composition of natural gas hydrocarbon molecular weight, mole fraction, pseudo-critical temperature, and pressure for each component and gas composition of the Wafa field have been used for fluid properties estimation listed in Table 1. Reservoir formation temperature (T) and pressure (P) are 26.28 °C and 3.40 MPa have been used for reservoir Wafa fluid analysis. In the present research to complete the analysis properly. As shown in the Table 1[10].

TABLE 1.Critical properties and Mole Fraction of defined Component[10]

Component	Molecular weight	Critical Pressure P_{ci} (Psia)	Critical Temperature T_{ci} (R°)	Mole fraction Y_i
C_1	16.04	343	668	0.86071
C_2	30.07	550	709	0.09953
C_3	44.10	666	617	0.01142
i-c_4	58.12	735	530	0.00032
n-c_4	58.12	765	551	0.00028
i-c_5	72.15	830	490	0.00000
n-c_5	72.15	845	487	0.00000
C_6	86.18	913	434	0.00000
H_e	4.00	9	33	0.00094
O_2	31.99	279	737	0.00000
H_2	2.02	60	188	0.00000
N_2	28.01	227	493	0.00483
CO_2	44.01	548	1073	0.01898
H_2S	34.08	673	1306	0.00000

4. Methodology

There are several simulation packages available, but Aspen Hysys provides one of the best process modeling environments for conceptualizing and improving oil and gas process operations. This modeling tool has been used by researchers and engineers for decades to achieve better engineering design and energy efficiency. Therefore, the choice fell to Aspen Hysys. The Peng-Robinson thermodynamic model was selected as the fluid property package. The gas processing method employs the use of a number namely; Mixers and separators (main separator, compressor, and heat exchanger) [11].

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5. Simulation and Calculation

Flash calculations are used for vapor/liquid equilibrium (VLE) processes. A characteristic process that requires flash calculations is the separation of a feed stream (F) into a vapor (V) and a liquid output (L). As seen Figure 2.

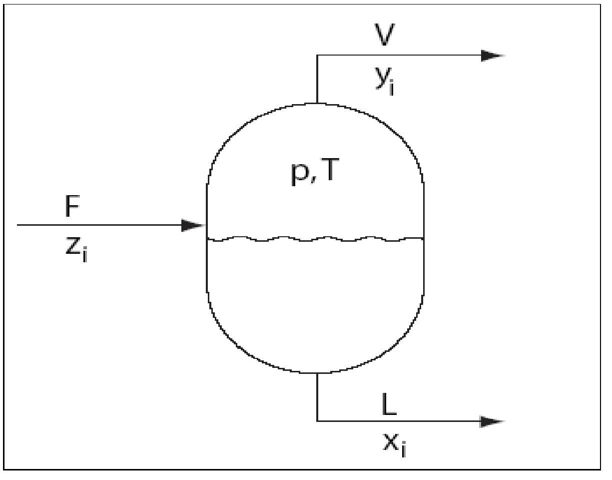

Figure 2: Flash Separator

In standard, flash calculations are straightforward and involve combining the VLE-equations with the component mass balances, and in some cases the energy balance. Next, consider a flash where a feed F (with composition z_i) is split into a vapor product V (with composition y_i) and a liquid product (with composition x_i); see Figure 1. For each of the Nc components, we can write a material balance.

$$F_{z_i} = L_{x_i} + V_{y_i} \qquad (1)$$

$$x_i = \frac{z_i}{1+\frac{V}{F}(K_i - 1)} \qquad (2)$$

It is also assumed that the vapor and liquid are in equilibrium.

$$y_i = K_i x_i \qquad (3)$$

The values of K $K_i = K_i(T, P, x_i, y_i)$ are calculated from the VLE model. Furthermore, we have the two relations $\sum_i x_i = 1$ and $\sum_i y_i = 1$. For a specified feed (F, z_i) we then

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have $3Nc+2$ equations in $3Nc+4$ unknowns (x_i, y_i, K_i, L, V, T, P). Therefore, we need two additional specifications with which the set of equations should be solvable. The simplest flash is typically to detail p and T (flash pT) since K_i depends mainly on p and T. Let's show an ordinary approach to solve the resulting equations that have good numerical properties. Substituting $y_i = K_i x_i$ into the mass balance on equation (1) gives $Fz_i = Lx_i + V K_i x_i$, and solving for x_i gives $x_i = (Fz_i/(L + VK_i)$. Here we introduce $L = F - L$ (mass balance total).Here, we cannot straight calculate x_i because the vapor crack V/F is not recognized. To find V/F we may use the relationship $\sum_i x_i = 1$ or alternatively $\sum_i y_i = \sum_i K_i x_i = 1$.However, it was found that the grouping $\sum_i (y_i - x_i) = 0$ leads to an equation with good quality numerical properties; This is the so-called Rachford-Rice-Flash equation [12].

$$\sum_i \frac{z_i(K_i-1)}{1+\frac{V}{F}(K_i-1)} = 0 \qquad (4)$$

Which is a monotonic function in V/F and is thus simple to solve numerically. An objective solution must assure $0 \le V/F \le 1$. If we assume that Raoult's holds, then K_i depends on p and T only: $K_i = P_i^{sat}(T)/P$. Then, with T and p specified, we know K_i, and the Rachford-Rice equation can be solved for V/F. For non-ideal cases, K_i depends also on $x_i$and y_i, so one approach is to add an outer iteration loop on K_i.

6. Results and Discussions

Table 1 shows the results of the chemical composition of the hydrocarbons that make up the natural gas mixture in all lines and paths of the compression and separation unit. We note the change in the composition of methane gas from the entry point (0.86070) and exit from the vapor line with a value of (0.94826).We also see the Figure 3 showing the results obtained from the separator for the molar composition of natural gas.

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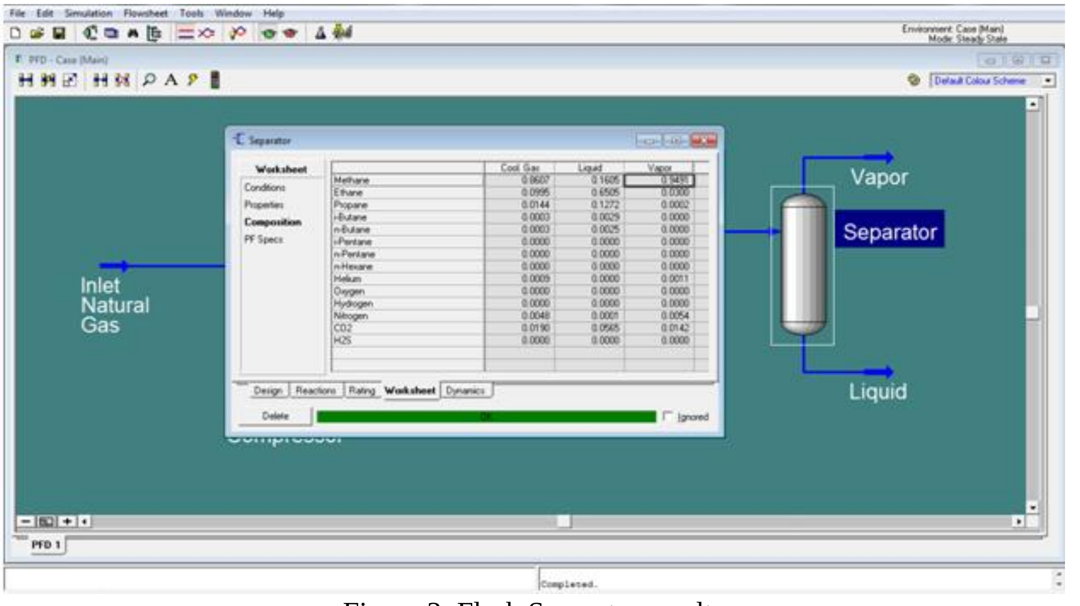

Figure 3: Flash Separator results

TABLE 2. Results of Composition Streams

Composition Streams					
Component	**Inlet Gas**	**Comp Gas**	**Cool Gas**	**Vapor**	**Liquid**
Methane	0.86070	0.86070	0.86070	0.94826	0.15839
Ethane	0.09953	0.09953	0.09953	0.03067	0.65182
Propane	0.01442	0.01442	0.01442	0.00019	0.12855
i-Butane	0.00032	0.00032	0.00032	0.00000	0.00288
n-Butane	0.00028	0.00028	0.00028	0.00000	0.00252
i-Pentane	0.00000	0.00000	0.00000	0.00000	0.00000
n-Pentane	0.00000	0.00000	0.00000	0.00000	0.00000
n-Hexane	0.00000	0.00000	0.00000	0.00000	0.00000
Helium	0.00094	0.00094	0.00094	0.00106	0.00000
Oxygen	0.00000	0.00000	0.00000	0.00000	0.00000
Hydrogen	0.00000	0.00000	0.00000	0.00000	0.00000
Nitrogen	0.00483	0.00483	0.00483	0.00543	0.00006
CO_2	0.01898	0.01898	0.01898	0.01439	0.05578
H_2S	0.00000	0.00000	0.00000	0.00000	0.00000

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TABLE 3. Results of Material Streams

Material Stream					
Name	**Inlet Gas**	**Comp Gas**	**Cool Gas**	**Vapor**	**Liquid**
Vapor Fraction	1	1	0.889146	1	0
Temperature [°C]	26.28	71.67498	-126.7687	-126.7687	-126.76867
Pressure [kPa]	101.325	168.7052	168.7052	168.7052	168.70515
Molar flow rate [kg mol/h]	100	100	100	88.91463	11.085366
Mass Flow [kg/h]	1844.608	1844.608	1844.608	1505.613	338.9953
Liquid Volume Flow [m^3/h]	5.70608	5.70608	5.70608	4.838022	0.8680575
Heat Flow [kJ/h]	-8192415	-8014115	-8910115	-7523010	-1387105.3

Table 3.Shows the characteristics and condition of all streams at the unit. Figures 3 to 7 show finding the composition of natural gas with several models of the EOS equation of state.
We notice here that all the shapes and graphs are almost very similar, and from here we conclude that the difference in effect between all these equations is very simple. The Ping-Robinson equation was chosen because it is more permissible to use for most chemical compounds and with a larger range of pressure and temperature.

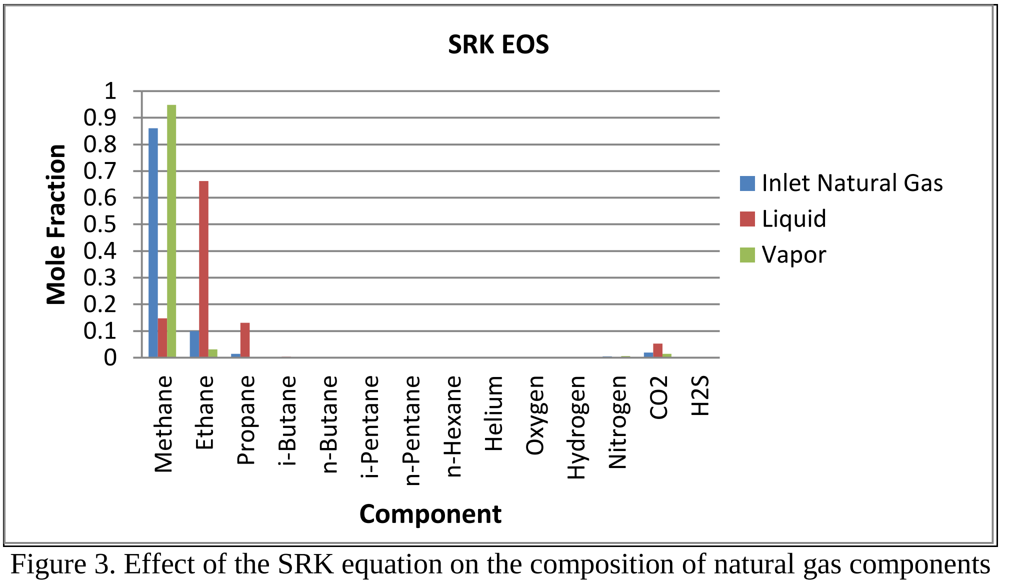

Figure 3. Effect of the SRK equation on the composition of natural gas components

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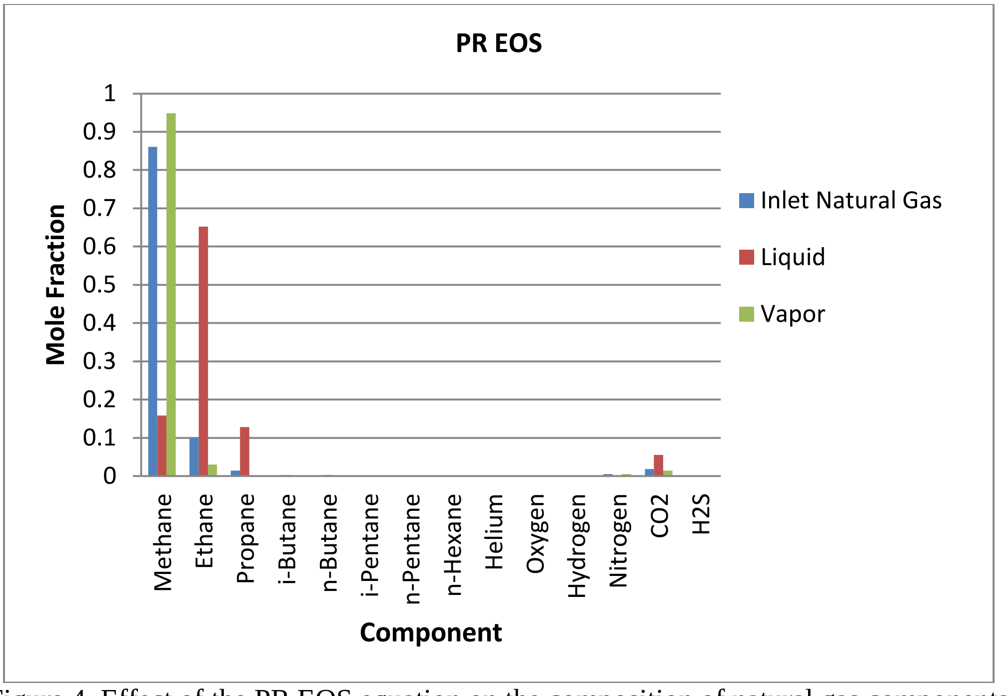

Figure 4. Effect of the PR EOS equation on the composition of natural gas components

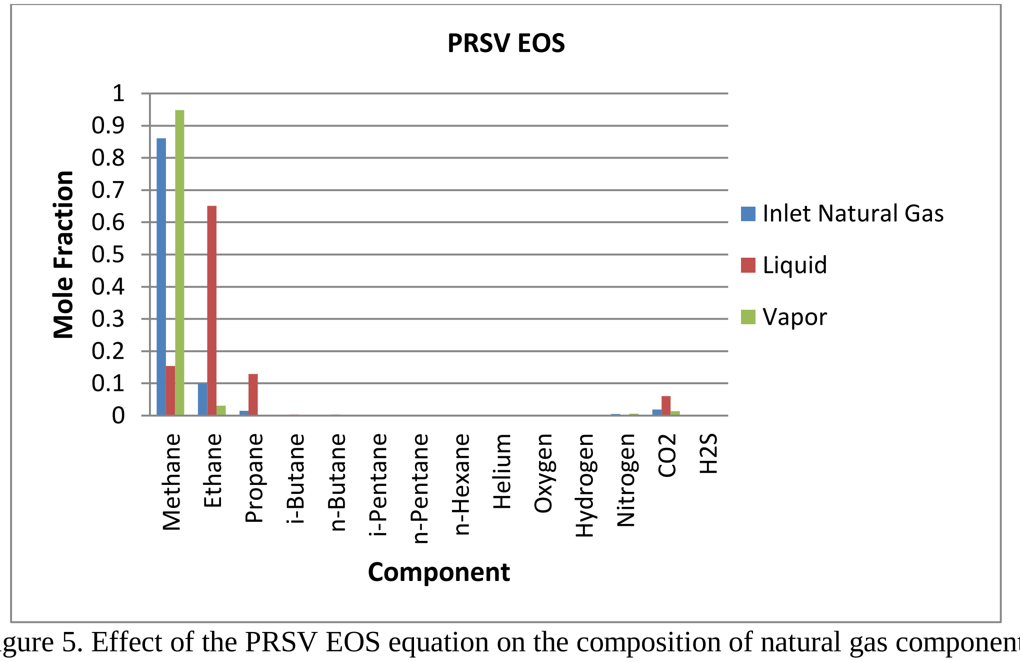

Figure 5. Effect of the PRSV EOS equation on the composition of natural gas components

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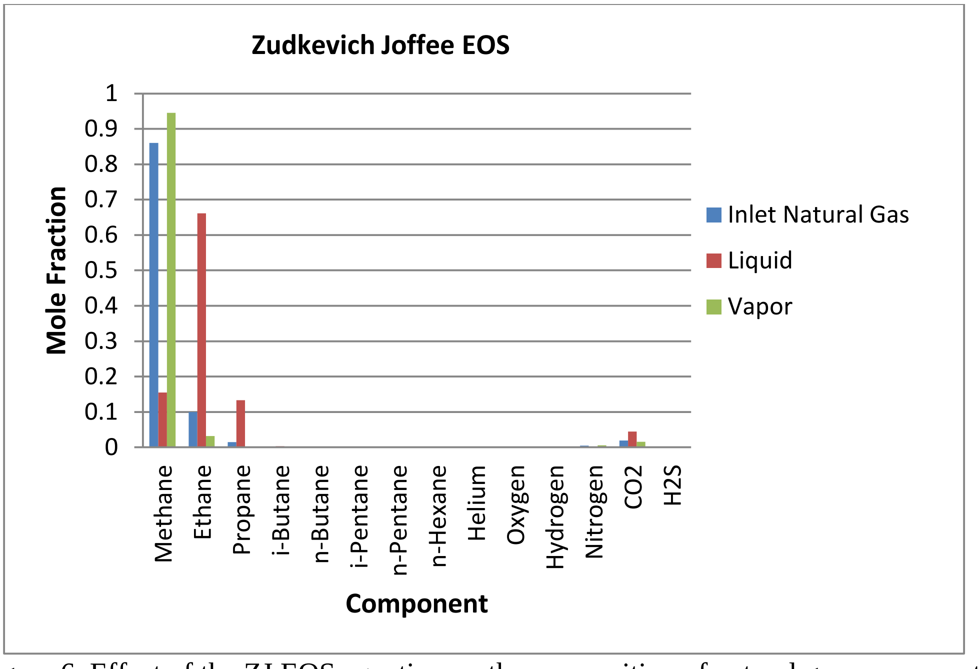

Figure 6. Effect of the ZJ EOS equation on the composition of natural gas components

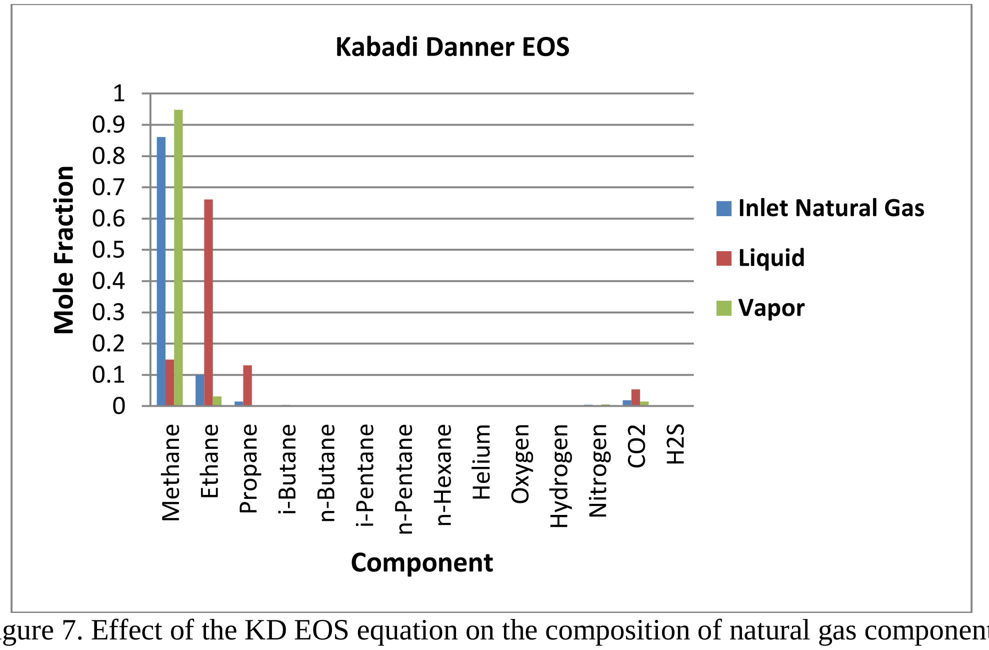

Figure 7. Effect of the KD EOS equation on the composition of natural gas components

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Figure 8 shows the effect of the decrease in pressure in the cooler on the concentration of methane gas produced. This appears in the long term as a result of the gradual decrease in the flow rate in the cooler resulting from deposits and corrosion factors in the cooler.

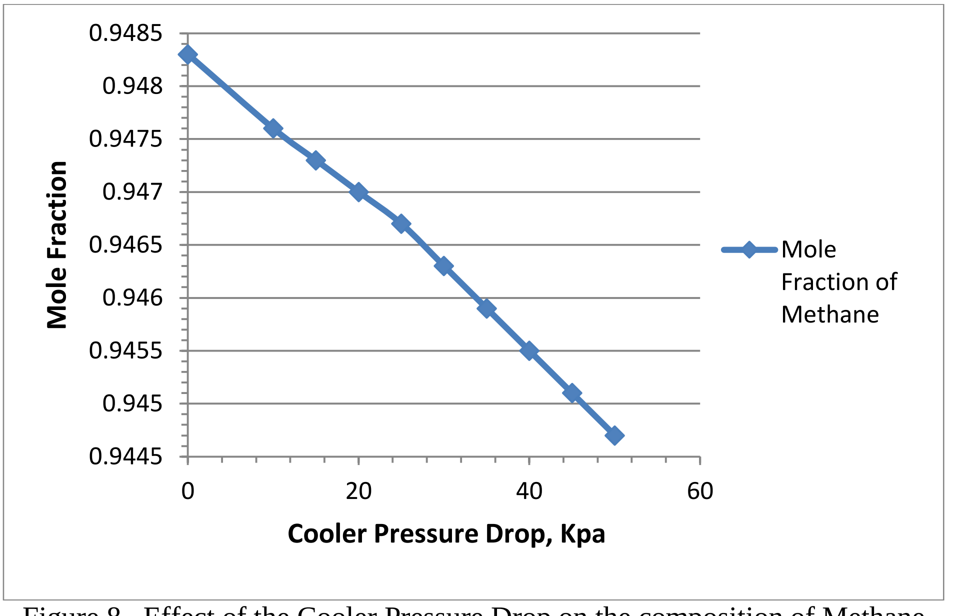

Figure 8. Effect of the Cooler Pressure Drop on the composition of Methane

Conclusions

1. In this research, a simulation model of a natural gas processing unit was run, and the required results were determined according to the data necessary for operation.
2. The simulation results will be compared with natural gas processing plant equipment.
3. The process improves operating conditions, which increases the overall profit of the process and reduces loss, like any industrial process and modification of the factory equipment used.
4. Also, from the results obtained in this research, one can rely on the use of state equations in design and calculations for this purpose to bring the results closer together.

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