The possibility of using associated gases of the khabaz oil field in supporting the production of electrical energy

إمكانية استخدام الغازات المصاحبة للنفط في حقل خبايز النفطي في دعم أنتاج الطاقة الكهربائية

Sinan Abdulrazzaq Baker
North Oil Company (NOC)

Abstract

This research includes a study of the components of the associated gases in khabaz oil field using Gas Chromatography instrument type (Varian cp-3800).

Results of the analysis of the associated gases showed that the methane (CH₄) is a (75%), while the hydrogen sulfide (H₂S) is (2%).

The samples of the associated gases were collected from the inside of the khabaz station and from the (Line A - 5), which provides North Gas Company of associated gases, is a mixture of gases coming from gas compressing stations (north & south Bai Hassan, Daodgorga, Ajil station and khabaz station).
Can take advantage of associated gas after treatment it in the North Gas Company for several purposes such as feeding power plant Mulla Abdullah, fuel gas for the operating units, production of sulfur and LPG.

The productivity of khabaz oil field at the present time of the associated gas is (28-34 mmscf / day).

The amount of the associated gases that burned in (flare) in khabaz oil field is (4 mmscf / day). The density of the flaring gas is (0.000921gm / cm³) where \( m_{gas} = \rho_{gas} \times v_{gas} \), the (1 mmscf) of gas equivalent to (26 ton), the flaring associated gas rate in khabaz oil field equivalent to (104 ton / day), which is enough to generate (8.4 megawatt) of electrical energy.

**Keywords** khabaz oil field, associated gases, flares.

**Introduction**

Energy is already the cornerstone of Iraq’s economy, with oil exports accounting for 95% of government revenues.

Natural gas can play a much more important role in Iraq’s future, reducing the dominance of oil in the domestic energy mix. Gathering and processing Iraq’s associated gas much of which is currently flared – will be a vital step.

One of the main obstacles to Iraq’s economic and social development is the lack of reliable electricity supply.

Associated gas in the south has a relatively high content of natural gas liquids (NGLs). The gas produced in the north is somewhat drier, but also requires treatment in order to make the gas marketable.

Due to the higher revenues earned by the oil sector, gas has historically been a secondary consideration for the Iraqi government, but attention to gas is growing as domestic demand increases, in particular for power generation [1].

The Khabaz oil field is one of the gaint Iraqi oil fields. This field is characterized by multiple pay zones similar to most of the northern Iraq oil fields, which produces from Tertiary and Cretaceous [2].

The Khabaz oil field was operated in 1990 (According to North Oil Company data), The Khabaz oil field contains large quantities of oil and gas. It consists of (37) oil wells, in addition to oil, these wells produce large quantities of associated gases about (28-35 mmscf / day).

Large amount of associated gases are burned in the air to dispose of them and constitute about 40% of the total production of the field.
Khabaz oil field located 23 km to the west to northwestern of Kirkuk city in north Iraq. The Kirkuk-based North Gas Company operates twenty-three degassing stations at oil and gas fields across central and northern Iraq.

Twelve gas-compressor stations collect associated gas before feeding it to a gas processing plant at Kirkuk to produce LPG, dry gas, natural gasoline, and sulfur.

The most important non-associated gas deposits are Anfal, Chemchemal, Khashim al Ahmar, JeriaPika and Mansouriyah in the North, the Sibba field South of Bashrah and the Akkas field in the Western desert (close to the Syrian border) [3].

flaring Associated gas is one of the most challenging energy and environmental problems facing the world today. Approximately 150 billion cubic meters of natural gas are flared in the world each year, representing an enormous waste of natural resources and contributing 400 million metric tons of CO₂ equivalent global greenhouse gas emissions.

Associated gas, or solution gas, separates from the oil as a result of the pressure change between the oil producing formation and the surface [4].

Global flaring and venting of petroleum-associated gas is a significant source of greenhouse gas emissions and airborne contaminants that has proven difficult to mitigate over the years. In the petroleum industry, poor efficiency in the flare systems often result in incomplete combustion which produces a variety of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and inorganic contaminants [5].

Table (1) shows the top 20 countries in petroleum industry, Iraq in this table comes in the 4th step of flaring countries in 2004.
Table (1) Top 20 flaring countries in 2004 [6].

| Rank 2004 | Country       | Reported Flaring , 2004 (bcm) |
|-----------|---------------|-------------------------------|
| 1         | Nigeria       | 24.1                          |
| 2         | Russia        | 14.7                          |
| 3         | Iran          | 13.3                          |
| 4         | Iraq          | 8.6                           |
| 5         | Angola        | 6.8                           |
| 6         | Qatar         | 4.5                           |
| 7         | Algeria       | 4.3                           |
| 8         | Venezuela     | 3.7                           |
| 9         | Equatorial Guinea | 3.6                      |
| 10        | Indonesia     | 3.5                           |
| 11        | USA           | 2.8                           |
| 12        | Kazakhstan    | 2.7                           |
| 13        | Libya         | 2.5                           |
| 14        | Azerbaijan    | 2.5                           |
| 15        | Mexico        | 1.6                           |
| 16        | UK            | 1.6                           |
| 17        | Brazil        | 1.5                           |
| 18        | Gabon         | 1.4                           |
| 19        | Cameroon      | 1.1                           |
| 20        | Canada        | 1.0                           |

To reduce flaring Iraq’s state-owned South Gas Company (51%) signed an agreement with partners Royal Dutch Shell (44%) and Mitsubishi (5%) to create a new joint venture, Basrah Gas Company, to capture flared gas at three large southern oil fields-Rumaila, West Qurna and Zubair.

Iraq and Royal Dutch Shell recently made some progress utilizing associated natural gas that was previously flared at the supergiant Majnoon oil field in Basra operated by Royal Dtc Shell (45%), in partnership with Malaysia’s Petronas (30%) and Iraq’s Missan Oil Company (25%). Starting in February 2016, associated gas produced at Majnoon is being sent to processing facilities in Basra to produce 300 megawatts of electricity for Iraq’s power grid.

Iraq is taking steps to reduce flaring and instead use its natural gas resources more for power generation.
and for reinjection into wells to enhance oil recovery, about three-quarters of Iraq’s natural gas reserves are associated with oil, most of which lie in the supergiant fields in the south.

Iraqi gross natural gas production was (771 billion cubic feet) in 2014, of which 454 bcf was flared, according to OPEC’s Annual Statistical Bulletin in 2014 [7].

The primary purpose of gas flaring is to act as a safety device to protect vessels or pipes from overpressuring due to unplanned upsets [8].

Iraq’s proven gas reserves are concentrated in the south, mostly at the large associated gas reserves in the giant fields of Rumaila, West Qurna, Majnoon, NahrUmr and Zubair [9]. Combustion (flaring and incineration) or venting can cause local and regional air pollution. Combustion emits carbon dioxide, a greenhouse gas that contributes to global warming. Venting releases methane, which has 23 times as much global warming potential as carbon dioxide [10].

The first scientist to recognize chromatography as an efficient method of separation was the Russian Mikhail Tsvet, who employed a primitive from of liquid solid chromatography to separate and isolate various plant pigments. Chromatography was actually discovered by Tsvet in the late 1890s [11].

The development of gas chromatography was enormously accelerated by the introduction in 1952 of gas – liquid chromatography by James and Martin [12].

**The aim** of the present work is to study the composition of associated gas in khabaz oil field using Gas Chromatography instrument type (Varian cp-3800), as well as studying the possibility of using the associated gases in khabaz oil field in the generation of electricity instead of burning.

**Experimental work:**

The sample was collected from the North Gas Company (NGC) A-5LINE dated 8th January / 2017, second sample from Khbbaz / Compressor station (Contactor Out Let) dated 29th December / 2013, third sample from KHbbaz Degassing Station dated 12th November / 2013, fourth sample from flare gas (KHbbaz oil field) dated 7th March / 2016, then we took two samples from north gas company (A-5 LINE) for months (April, August) / 2016, The type of the Detector is TCD, Type of Column is Packed Column his specification as in the table (2) below.

**Table (2) Specification of the Column of the instrument (Gas Chromatography) type (VARIAN CP-3800).**

| Material                  | Stainless steel |
|---------------------------|-----------------|
| Length                    | 12 meter        |
| Outside Diameter (O.D)    | 1/8             |
| Inside Diameter (I.D)     | 2mm             |
Fig. (1) Gas Chromatography instrument.

Table (3) The samples.

| NO | Source of samples                                      | Date of sampling        |
|----|--------------------------------------------------------|-------------------------|
| 1  | North Gas Company (NGC), A-5LINE                       | 8\textsuperscript{th} January / 2017 |
| 2  | Khbbaz Compressor station (Contactor Out Let)          | 29\textsuperscript{th} December / 2013 |
| 3  | Khbbaz Degassing Station                               | 12\textsuperscript{th} November / 2013 |
| 4  | Khbbaz oil field / flaring gas                         | 7\textsuperscript{th} March / 2016 |
| 5  | Two samples from north gas company (A-5 LINE)          | (5\textsuperscript{th} April, 10\textsuperscript{th} August) / 2016 |

**Results & Discussion:**

Table (4) Shows the results of the analysis of the gas that taken from North Gas Company (N.G.C) (A-5LINE). From this table was noted that the amount of methane gas the highest in comparison with the other components, the amount of hydrogen sulfide is a few (2.09 % mole), also the amount of carbon dioxide is a few (2.47 % mole).
Table (4) Laboratory analysis of the North Gas Company (A-5LINE) gas on 08/01/2017.

By VARIAN CP-3800 GC INSTRUMENT

| Date of Sampling       | 08/01/2017 |
|------------------------|------------|
| Date of Testing        | 09/01/2017 |
| Source of Sample       | North Gas Company |
| Sampling Point         | (A-5 Line) |
| Sample Temp. (C°)      | 21.5       |
| Sample Press. (kg/cm²) | 28.5       |

Result of Analysis

| Component | Mole% |
|-----------|-------|
| N₂        | 0.00  |
| C₁        | 79.56 |
| CO₂       | 2.47  |
| C₂        | 10.24 |
| H₂S       | 2.09  |
| C₃        | 3.87  |
| iC₄       | 0.41  |
| nC₄       | 0.91  |
| iC₅       | 0.17  |
| nC₅       | 0.16  |
| C₆⁺       | 0.12  |
| Total     | 100.00|
| Ton LPG / MMSCF | 2.96 |
| Mwt       | 20.46 |
| Density (gm /cc)   | 0.000864|
| SP. gr            | 0.7063 |

Table (5) shows the change of the gaseous components in the Khbbaz oil field (A-5LINE) for months (August, April / 2016) in accordance with the Laboratory analysis. From this table it was noted that the amount of the methane for two months is convergent and the highest in comparison with the other components, the amount of both the hydrogen sulfide and carbon dioxide is low compared with the other fields, then, it is clear that the propane, normal butane and isobutene high amount in comparison.
with the gas that taken from A-5LINE on 08/01/2017.

Table (5) Laboratory analysis of the Khbbaz oil field (A-5Line) gas for months (August, April / 2016).

| Date of Sampling | 10/08/2016 | 05/04/2016 |
|------------------|------------|------------|
| Date of Testing  | 11/08/2016 | 06/04/2017 |
| Source of Sample | North Gas Company |
| Sampling Point   | (A-5 Line)  |
| Sample Temp. (C°) | 33         | 28         |
| Sample Press. (kg/cm²) | 27   | 20         |

**Result of Analysis**

| Component | Mole% | Mole% |
|-----------|-------|-------|
| N₂        | 0.00  | 0.00  |
| C₁        | 76.02 | 78.51 |
| CO₂       | 3.15  | 2.14  |
| C₂        | 10.47 | 11.53 |
| H₂S       | 2.45  | 1.39  |
| C₃        | 4.82  | 4.10  |
| iC₄       | 0.62  | 0.49  |
| nC₄       | 1.41  | 1.08  |
| iC₅       | 0.35  | 0.29  |
| nC₅       | 0.36  | 0.31  |
| C₆⁺       | 0.35  | 0.16  |
| Total     | 100.00| 100.00|
| Ton LPG / MMSCF | 3.95 | 3.25 |
| M_wt      | 21.68 | 20.77 |
| Density (gm/cc) | 0.000091 | 0.000877 |
| SP. gr    | 0.7487| 0.7171 |
Table (6) shows the results of the analysis of the gas that taken from Khbbaz oil field / Contactor Outlet dated 29th December / 2013. From this table was noted that the amount of methane the highest in comparison with the other components, the amount of hydrogen sulfide is a few (2.09 % mole), also the amount of carbon dioxide is a few (2.47 % mole).

Table (6) Analysis of the KZ / Compressor Station / Contactor Outlet dated 29th December / 2013.

| By VARIAN CP-3800 GC INSTRUMENT                                      |
|---------------------------------------------------------------------|
| Date of Sampling                                                   | 29/12/2013 |
| Date of Testing                                                    | 29/12/2013 |
| Source of Sample                                                    | KZ / Compressor Station |
| Sample Temp. (C°)                                                   | 27         |
| Sample Press. (kg/cm²)                                              | 32         |

Result of Analysis

| Sampling Point | CONT . OUTLET |
|----------------|---------------|
| Component      | Mole %        |
| N₂             | 0.00          |
| C₁             | 76.60         |
| CO₂            | 3.22          |
| C₂             | 10.92         |
| H₂S            | 2.16          |
| C₃             | 4.55          |
| iC₄            | 0.54          |
| nC₄            | 1.10          |
| iC₅            | 0.38          |
| nC₅            | 0.31          |
| C₆+            | 0.22          |
| Total          | 100.00        |
| Ton LPG / MMSCF  | 3.54         |
| Mwt            | 21.37         |
| Density (gm /cc)      | 0.000903      |
| SP. gr          | 0.7379        |

Table (7) shows the results of the gas analysis at different stages of degassing the associated gas in Khbbaz oil field (Degassing station) dated 12th November / 2013. It was noted that the amount of methane decreases with each stage, while the other components increases. Also it was noted the amount of the hydrogen sulfide is a few while the methane is highest from other components.
Table (7) Laboratory analysis of the Khbbaz oil field (Degassing station) on 12/11/2013

| Date of Sampling       | 12/11/2013 |
|------------------------|------------|
| Date of Testing        | 13/11/2013 |
| Source of Sample       | Khbbaz Degassing station |
| Sample Temp. (°C)      | 18 70 30 |
| Sample Press. (kg/cm²) | 13 3.1 0.035 |

Result of Analysis

| Sampling Point | 1st stage degas | 2nd stage degas | 3rd stage degas |
|----------------|-----------------|-----------------|-----------------|
| Component      | Mole%           | Mole%           | Mole%           |
| N₂             | 0.00            | 0.00            | 0.00            |
| C₁             | 77.73           | 39.62           | 28.64           |
| CO₂            | 2.03            | 2.00            | 1.31            |
| C₂             | 11.12           | 16.49           | 19.61           |
| H₂S            | 1.17            | 3.10            | 2.50            |
| C₃             | 4.98            | 14.62           | 16.00           |
| iC₄            | 0.60            | 2.82            | 4.12            |
| nC₄            | 1.41            | 9.50            | 12.22           |
| iC₅            | 0.33            | 3.33            | 3.60            |
| nC₅            | 0.41            | 4.46            | 5.10            |
| C₆₊            | 0.22            | 4.06            | 6.90            |
| Total          | 100.00          | 100.00          | 100.00          |
| Ton LPG / MMSCF | 4.02           | 16.27           | 19.79           |
| Mₜₜ            | 21.19           | 35.98           | 40.69           |
| Density (gm /cc) | 0.000895        | 0.001519        | 0.001719        |
| SP. Gr          | 0.7318          | 1.2421          | 1.4050          |

Table (8) shows the amount of the components of flaring gas in the Khbbaz oil field dated 7th March 2016, it was noted the amount of methane is (73.87 mole %) from other components and noted the amount of propane is (5.25 mole %) which is a high amount in comparison with the amount of produced gas from (A-5Line), The amount of hydrogen sulfide and carbon dioxide were a few.
Table (8) Analysis of the flaring gas in the Khbbaz oil field on 7th March/2016.

By VARIAN CP-3800 GC INSTRUMENT

| Date of Sampling       | ’07/03/2016   |
|------------------------|--------------|
| Date of Testing        | 08/03/2016   |
| Source of Sample       | Khbbaz       |
| Sample Temp. (C°)      | —            |
| Sample Press. (kg/cm²) | 2.0          |

**Result of Analysis**

| Sampling Point | Flare Line |
|----------------|------------|
| Component      | Mole %     |
| N₂             | 2.98       |
| C₁             | 73.87      |
| CO₂            | 1.41       |
| C₂             | 11.99      |
| H₂S            | 1.12       |
| C₃             | 5.25       |
| iC₄            | 0.80       |
| nC₄            | 1.22       |
| iC₅            | 0.49       |
| nC₅            | 0.55       |
| C₆+            | 0.30       |
| Total          | 100.00     |
| Ton LPG / MMSCF| 4.18       |
| Mₐrt           | 21.80      |
| Density (gm/ cc)| 0.000921  |
| SP. Gr          | 0.7528     |

The following equation must be used to calculate the mass each component of the gas components, it is possible estimation the amount of the energy through equations below [13].

\[
X = \frac{n_i}{n} \quad \text{------------------------ (1)}
\]

Where:

\(X\) = molar fraction

\(n\) = The total number of moles of gas

\(n_i\) = The number of moles of gaseous component

\[
X = \frac{m_i}{m} \quad \text{------------------------ (2)}
\]

Where:

\(X\) = mass fraction,  \(m_i\) = Mass gaseous component,

\(m\) = The total mass of gases.
\[ m_i = n_i \times M_i \] ---------------------------------------- (3)

Where:

\( M_i \) = Molecular weight of the gaseous component [13].

| (i) component | Symbol | \( M_i \) | \( n_i \) | \( X_i \) |
|---------------|--------|-----------|-----------|---------|
| Nitrogen      | N\(_2\) | 28        | 2.98      | 3.827   |
| Methane       | C\(_1\) | 16.04     | 73.87     | 54.352  |
| Carbon Dioxide| CO\(_2\) | 44        | 1.41      | 2.845   |
| Ethane        | C\(_2\) | 30.07     | 11.99     | 16.538  |
| Sulfur Hydroxide | H\(_2\)S | 32        | 1.12      | 1.644   |
| Propane       | C\(_3\) | 44.09     | 5.25      | 10.618  |
| i-Butane      | i-C\(_4\) | 58.12    | 0.80      | 2.132   |
| n-Butane      | n-C\(_4\) | 58.12    | 1.22      | 3.252   |
| i-Pentane     | i-C\(_5\) | 72.15    | 0.49      | 1.621   |
| n-Pentane     | n-C\(_5\) | 72.15    | 0.55      | 1.820   |
| Hexane        | C\(_6\) | 86.17     | 0.30      | 1.185   |
| Total         | -----   | -----     | 100.00    | 100.00  |

It is possible to calculate the total mass of the gas through the following equation:

\[ m_{gas} = \rho_{gas} \times v_{gas} \] ---------------------------------------- (4)

Where:

\( m_{gas} \) = mass of gas (gm), \( \rho_{gas} \) = density of gas (gm/cm\(^3\)), \( v_{gas} \) = the volume of gas (cm\(^3\)).

The amount of the associated gases that burned in (flare) in khbbaz oil field is (4 mmscf / day), and the density of the associated gases that burned in (flare) is (0.000921 gm / cm\(^3\)) where (\( m_{gas} = \rho_{gas} \times v_{gas} \)), the (1 mmscf) of gas equivalent to (26 ton), the amount of the flaring associated gas in khbbaz oil field equivalent to (104 ton / day) and this is not constant and may increase up to (7 mmscf / day) (According to North Oil Company data).

It is possible to calculate the thermal energy that can be provided through the use of gas as a fuel as following equation:

\[ Q^o = m^o_{gas} \times Q_{HV} \] ---------------------------------------- (5)

Where \( Q^o = \) the amount of heat generated (kW), \( m^o_{gas} = \) mass of gas (kg / sec), \( Q_{HV} = \) calorific value of the gas (mJ / kg).

And the power resulting from the gas turbine is calculated by the following equation [14].

\[ \text{Power} = Q^o \times \eta_{th} \] ----------------------------------------(6)
Where $\eta_{th}$ = thermal efficiency of the turbine.

Considering that 50% by weight of the flaring gas is methane by laboratory analysis so we can calculate the amount of electrical energy can be produced by the gas turbine, which efficiency more than 35% [12].

$$m°_{gas} = (52 \times 1000) \text{ kg / day} \times \frac{1 \text{ day}}{(24 \times 60 \times 60)} = 0.60 \text{ kg / sec},$$

$$Q = m°_{gas} \times Q_{HV}, \quad Q° = 0.60 \text{ kg / sec} \times 40 \text{ mJ/kg} = 24 \text{ mJ/sec},$$

Power = $Q° \times \eta_{th} = 24 \text{ mJ / sec} \times 0.35 = 8.4 \text{ megawatt}.$

If use flaring gas correct we will get the (8.4 megawatt) to the electricity sector.

**Conclusions**

1- It was noted that the methane for gas composition was about 75%.

2- The gas produced in the Khbbaz oil field at the present time is (34 mmscf / day) (884 ton / day), and the amount of methane up to 50% which is equivalent to (442 ton / day).

3- We don't have the Technology to liquefy and storage methane gas.

4- (1 mmscf) of the associated gas equivalent to (26 ton) and the amount of the daily burned of it in the flare in the Khabaz oil field is 4 mmscf / day (104 ton/day), that means a large losing of energy. The amount of methane alone enough to generate (8.4) megawatt of electricity.

**Nomenclature**

mmscf = million standard cubic foot

bcm = billion cubic meter

VOCs = volatile organic compounds
References

1. International Energy Agency (iea), Iraq Energy Outlook, World Energy Outlook Special Report, 2012.
2. Fuad Mohammad Qader, 1999, Formation Evaluation of Upper Qamchuqa Reservoir Khabbaz Oil Field Kirkuk Area North Astern Iraq, University of Sulaimani.
3. Nadia Kanaan, 2014, Report about Oil & Gas Sector in Iraq, Iraqi Ministry of oil, Technical Directorate.
4. Michael F. Farina, 2010, Flare Gas Reduction, GE Energy.
5. Aniefiok E. Ite, Udo J. Ibok, Gas Flaring and Venting Associated with Petroleum Exploration and Gas Flaring and Venting Associated with Petroleum Exploration and Production in the Nigeria’s Niger Delta, 2013, American Journal of Environmental Protection, Vol. 1, No. 4, 70-77.
6. ها. ديل بيكز، عملية إنتاج الغاز، 1985، ترجمة الدكتور حازم حسن عبد الكريم العطار، كلية الهندسة، جامعة بغداد.
7. International Energy Agency (iea), Country Analysis Brief: Iraq, April 28, 2016.
8. BO Nordell, 2007, Gas Flaring Emission Contributes to Global Warming, LULEA University of Technology, Sweden.
9. Peter Prisecaru, AL Dula imi Haidar Ali, 2014, Natural Gas Boom in the Middle East, College of Economic & Administration, University of Al-Qadisiya.
10. Robert D. Bott, 2007, Flaring: Question + Answers, second edition, Canadian Center for Energy Information.
11. A. B. Littlewood, 1970, gas chromatography, second edition, The University of Newcastle upon Tyne, England.
12. Raymond P. W. Scott, 1998, Introduction to Analytical Gas Chromatography, second edition, Georgetown University, Washington, USA.
13. راينر جول، 1984، الأساليب الهندسية لديناميكي الحرارة بالوحدات العالمية، (ترجمة) الكلية الفنية العسكرية، العراق.
14. الربعي حسن، 2003، دراسة فاعلية تطوير المحطات الغازية إلى محطات ومرافق كهرو حرارية مزدوجة مخصصة لانتاج الطاقة الكهربائية ومنبج التحلية، بحث منشور مجلة (نقابة المهندسين الأردنيين).