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 خباز النفطي في دعم أنتاج الطاقة الكهربائية

Sinan Abdulrazzaq Baker

North Oil Company (NOC)

الخلاصة

تم التطرق في هذا البحث الى دراسة مكونات الغازات المصاحبة للنفط في حقل خباز النفطي ودراسة وتحليل الغازات التي يتم حرقها في المشاعل (flare) باستخدام جهاز Gas Chromatography نوع (Varian cp-3800).

اظهرت نتائج التحليل للغازات المصاحبة للنفط بأن نسبة غاز الميثان (CH_4) يشكل تقريباً (75%) من بقية المكونات الغازية الأخرى، بينما غاز كبريتيد الهيدروجين (H_2S) يشكل تقريبا (2%).

وقد تم اخذ نماذج للغاز المصاحب من داخل محطة خباز ومن الخط (A - 5 Line) وهذا الخط يقوم بتجهيز شركة غاز الشمال بالغازات المصاحبة وهو مزيج للغازات الواردة من محطات كبس الغاز (باي حسن الشمالي والجنوبي) ومحطة كبس داوود كركه ومحطة عجيل بالإضافة الى حقل خباز.

ويتم الاستفادة من الغازات المصاحبة بعد معالجتها في شركة غاز الشمال لاغراض متعددة منها تغذية محطة توليد كهرباء ملا عبدالله، كوقود (fuel gas) للوحدات التشغيلية، انتاج الكبريت و ال LPG.

ان انتاجية حقل خباز في الوقت الراهن من الغازات المصاحبة تبلغ بحدود (28- 34) مقمق/ يوم تقريباً.

اما بخصوص الغازات التي يتم حرقها في المشاعل (flare) في حقل خباز فتبلغ تقريباً (2-7) مقمق/ يوم، وكثافتها (0.000921 gm / cm^3) وبما ان

($m_{gas}= \rho_{gas} * v_{gas}$) عليه فأن كتلة (1 mmscf) من الغاز يعادل (26 طن) تقريباً وبالتالي فأن معدل حرق الغازات المصاحبة في حقل خباز النفطي على افتراض كمية الغازات المحترقة في المشاعل (4 مقمق/ يوم) تعادل (ton/day104) تقريباً والتي تكفي لتوليد (megawatt 8.4) من الطاقة الكهربائية.

الكلمات الدالة حقل خباز النفطي، الغازات المصاحبة، المشاعل (flare).

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 (CH_4) is a (75%), while the hydrogen sulfide (H_2S) 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 / cm^3) where ($m_{gas} = \rho_{gas} * v_{gas}$), 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 CO_2 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 4^{th} 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 Dtch 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 over-pressuring 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.

Expermental work:

The sample was collected from the North Gas Company (NGC) A-5LINE dated 8th Janury / 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

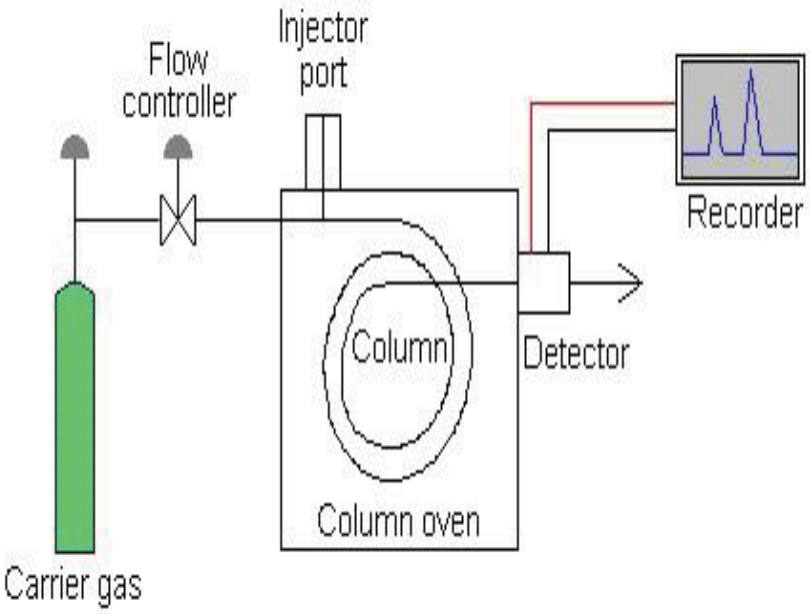

Fig. (1) Gas Chromatography instrument.

Table (3) The samples.

NO	Source of samples	Date of sampling
1	North Gas Company (NGC), A-5LINE	8th January / 2017
2	Khbbaz Compressor station (Contactor Out Let)	29th December / 2013
3	Khbbaz Degassing Station	12th November / 2013
4	Khbbaz oil field / flaring gas	7th March / 2016
5	Two samples from north gas company (A-5 LINE)	(5 th April, 10 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/cm^2)	28.5
Result of Analysis	
Component	Mole%
N_2	0.00
C_1	79.56
CO_2	2.47
C_2	10.24
H_2S	2.09
C_3	3.87
iC_4	0.41
nC_4	0.91
iC_5	0,17
nC_5	0.16
C_{6+}	0.12
Total	100.00
Ton LPG / MMSCF	2.96
M_{wt}	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).

By VARIAN CP-3800 GC INSTRUMENT		
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/cm^2)	27	20
Result of Analysis		
Component	Mole%	Mole%
N_2	0.00	0.00
C_1	76.02	78.51
CO_2	3.15	2.14
C_2	10.47	11.53
H_2S	2.45	1.39
C_3	4.82	4.10
iC_4	0.62	0.49
nC_4	1.41	1.08
iC_5	0.35	0.29
nC_5	0.36	0.31
C_{6+}	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 Out let 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/cm^2)	32
Result of Analysis	
Sampling Point	CONT . OUT LET
Component	Mole %
N_2	0.00
C_1	76.60
CO_2	3.22
C_2	10.92
H_2S	2.16
C_3	4.55
iC_4	0.54
nC_4	1.10
iC_5	0.38
nC_5	0.31
C_{6+}	0.22
Total	100.00
Ton LPG / MMSCF	3.54
M_{wt}	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

By VARIAN CP-3800 GC INSTRUMENT			
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/cm^2)	13	3.1	0.035
Result of Analysis			
Sampling Point	1st stage degas	2nd stage degas	3rd stage degas
Component	Mole%	Mole%	Mole%
N_2	0.00	0.00	0.00
C_1	77.73	39.62	28.64
CO_2	2.03	2.00	1.31
C_2	11.12	16.49	19.61
H_2S	1.17	3.10	2.50
C_3	4.98	14.62	16.00
iC_4	0.60	2.82	4.12
nC_4	1.41	9.50	12.22
iC_5	0.33	3.33	3.60
nC_5	0.41	4.46	5.10
C_{6+}	0.22	4.06	6.90
Total	100.00	100.00	100.00
Ton LPG / MMSCF	4.02	16.27	19.79
M_{wt}	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 (73.87mole %) 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 on7th 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/cm^2)	2.0
Result of Analysis	
Sampling Point	Flare Line
Component	Mole %
N_2	2.98
C_1	73.87
CO_2	1.41
C_2	11.99
H_2S	1.12
C_3	5.25
iC_4	0.80
nC_4	1.22
iC_5	0.49
nC_5	0.55
C_{6+}	0.30
Total	100.00
Ton LPG / MMSCF	4.18
M_{wt}	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].

$X = n_i / n$ ---------- (1)

Where:

X = molar fraction

n = The total number of moles of gas

n_i = The number of moles of gaseous component

$X = m_i / m$ ---------- (2)

Where:

X = mass fraction, m_i = Mass gaseous component,

m = The total mass of gases.

$m_i = n_i * M_i$ ---------- (3)

Where:

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

Table (9) Gaseous components according to the weighted fracture of the flaring gas in the Khbbaz oil field.

(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_2S	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:

$m_{gas} = \rho_{gas} * v_{gas}$---------- (4)

Where:

m_{gas} = mass of gas (gm), ρ_{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 khabaz oil field is (4 mmscf / day), and the density of the associated gases that burned in (flare) is (0.000921 gm / cm^3) where ($m_{gas} = \rho_{gas} * v_{gas}$), the (1 mmscf) of gas equivalent to (26 ton), the amount of the flaring associated gas in khabaz 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:

$Q^{\circ} = m^{\circ}_{gas} * Q_{HV}$ ----------(5)

Where Q° = the amount of heat generated (kW), m°_{gas} = mass of gas (kg / sec), QHV = calorific value of the gas (mJ / kg).

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

Power = $Q^{\circ} * \eta_{th}$ ----------(6)

Where η_{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 * 1000) kg / day * 1day / (24*60*60) = 0.60 kg / sec,

$Q^{\circ} = m^{\circ}_{gas} * Q_{HV}$, Q° = 0.60 kg / sec* 40 mJ/kg = 24 mJ/sec ,

Power = $Q^{\circ} * \eta_{th}$ = 24 mJ / sec * 0.35 = 8.4 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

VOC_s = 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 Fiel 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، عمليات انتاج الغاز، 1985، ترجمة الدكتور حازم حسن عبدالكريم 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 Dulaimi 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، الاساسيات الهندسية لديناميك الحرارة بالوحدات العالمية، (ترجمة) الكلية الفنية العسكرية، العراق.

14. الربيعي حسن، 2003، دراسة فاعلية تطوير المحطات الغازية الى محطات ومراكز كهروحرارية مزدوجة مخصصة لانتاج الطاقة الكهربائية ومياه التحلية، بحث منشور مجلة (نقابة المهندسين الاردنيين).