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Energy Losses Resulting from the Flaring of the Associated Gases of the (North&South) Jambour Oil Fields

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Abstract:

This research includes a study of the components of the associated gases in Jambour fields (North and South) using Gas Chromatography instrument type (Varian cp-3800),The associated gases of The Southern Jambour contains small amounts of hydrogen sulfide gas (H_2S) and it is a sweet gas, while the associated gasesof Northern Jambour field is much higher up to 4 % Mole according to the analysis that has done on the associated gas for both fields by (GC), also the results of the analysis show that methane ratio is 80% for both fields gases (north, south) and can take advantage of the associated gas of Southern Jambour fields to feed the operating units in North Oil Company, North Gas Company, and Mulla Abdulla Power plant. The productivity of Southern Jambour field at the present time of the associated gas is (130 MMSCF/day) while the production of Northern Jambour field is (60 MMSCF/day) and can take advantage of the associated gas of SouthernJambour field to operate gas stations, because it is asweetgas.The amount of the associated gas burned in (flare) of Jambour fields is (1-4 MMSCF / day), and assuming the density of the associated gas rate is 0.00086 gm / cm3) where ($m_{gas} = \rho_{gas} * v_{gas}$), the (1 MMSCF) of gas equivalent to (25 ton), the flaring associated gas rate in Jambour fields equivalent to (25 ton/ day).

Keywords: The Northern & Southern Jambour oil field, associated gas, gas flaring.

Introduction

Iraq has a great wealth of fossil discovered where gases, of which an estimated (110 TCF) and probable reserves estimated to (150 TCF) , and (70%) of it is associatedgas with oil production[1] .

Jambour oil field has 56 wells;43 Cretaceous wells up to 10,000 feet deep inside in Southern Jambour, and Northern Jambour has 13 Tertiary wells depth is 4,000 feet .Kirkuk city has many fields (Khabaz field, Bai Hassan fields, Khurmala field, Khurmur field, and Jambour fields ..... etc) and that most of these oil fields , but it produces large quantities of associated gas [2] .

The construction of gas and sulfur plant in Kirkuk is for the purpose of a fraction of the associated gas to cover the need ofcountry. Statistics at the time of the subjects of liquid gas, sulfur and manufacturing remained the greatest of these gases are burned in the air without interest.

In order to invest every molecule of gas oil fields was created North-South gas and gas giants complex to manufacture all gas wealth in the Northern and Southern fields and convert them into hard currency [3] .Jambour oil field was discovered in 1954 and located just 80 kilometers north of Kirkuk, parallel to Kirkuk oil field [4].Natural gas mainly consist of methane, although it can occur in nature as amixture with other hydrocarbons such as ethane, propane, butane and pentane, and with some impurities such as carbon dioxide, nitrogen, sulphur compounds and/or helium.These components are separated off methane in process plants near producing fields[5].Non-hydrocarbon components in natural gas are (nitrogen, carbon dioxide, hydrogen sulfide, helium, water vapor, carbonyl sulfide, carbon disulfide, sulfur and mercaptanes)[6].Raw natural gas comes from three types of wells:Oil wells, gas wells, and condensate wells. Natural gas that comes from oil wells is typically termed 'associated gas'. This gas can exist separate from oil in the formation (free gas), or dissolved in the crude oil (dissolved gas). Natural gas from gas and condensate wells, in which there is little or no crude oil, is termed 'non associated gas'.

Gas wells typically produce raw natural gas by itself, while condensate wells

Produce free natural gas along with a semi-liquid hydrocarbon condensate. Whatever the source of the natural gas, once separated from crude oil (if present) it commonly exists in mixtures with other hydrocarbons; principally ethane, propane, butane, and pentanes. In addition, raw natural gas contains water vapor, hydrogen sulfide (H2S),carbon dioxide, helium, nitrogen, and other compounds[7].

Natural gas that contains more than (1 grain) of H_2S /100 SCF called sour gas, Generally much more than this .

Natural gas in which the hydrogen sulphide content is less than (1 grain) per 100 SCF called sweet gas , methane is the prime compound in natural gas[8].

Associated gas- it is natural gas ,also known as gas-cap gas or dome gas, that overlies and is in immediate contact , but not in solution, with crude oil in a reservoir [9].

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.

The size and brightness of the resulting flame depend upon the amount of released flammable material. Steam can be injected into the flame to reduce the formation of black smoke. In order to keep the flare system functional, a small amount of gas is continuously burnt, like a pilot light, so that the system is always ready for its primary purpose as an over-pressure safety system[10].

Fig. (1) Gas Flaring

Combustion emits carbon dioxide, a greenhouse gas that contributes to global warming. Venting releases methane, which has 23 times as much global warming potential (per tonne) as carbon dioxide..

If the natural gas contains H2S, emissions sulphur dioxide (SO2), carbon disulphide (CS2) and carbonyl sulphide (COS).

Oxides of nitrogen such as nitric oxide (NO), and nitrogen dioxide (NO2) contribute to ground-level ozone (a component of smog) and acid deposition.

Under some circumstances, inefficient combustion of hydrocarbons may also produce volatile organic compounds(VOCs), which include a wide variety of hydrocarbon compounds heavier than ethane. (VOCs)combine with oxides of nitrogen in the presence of sunlight to create ground-level ozoneand smog [11].

The United States' demand for natural gas stood at (23.0 Tcf) for 2002 and is expected to continue to rise to approximately (31.3 Tcf) by 2025 according to the Energy Information Association (EIA) and others.

The principal components of natural gas are methane and ethane with varying amounts of heavier hydrocarbons including propane, butanes, pentanes, hexanes, heptanes and octane as well as carbon dioxide, hydrogen sulfide, oxygen and water vapor [12].

Table (1) typical raw gas compositions*

No.	component	Casinghead (Wet) Gas Mol %	Gas Well(Dry) Gas Mol%	CondensateWell Gas Mol%
1	Carbon Dioxide	0.63	-	-
2	Nitrogen	3.73	1.25	0.53
3	Hydrogen Sulfide	0.57	-	-
4	Methane	64.48	91.01	94.87
5	Ethane	11.98	4.88	2.89
6	Propane	8.75	1.69	0.92
7	Iso-Butane	0.93	0.14	0.31
8	n-Butane	2.91	0.52	0.22
9	iso-Pentane	0.54	0.09	0.09
10	n-Pentane	0.80	0.18	0.06
11	Hexanes	0.37	0.13	0.05
12	Heptanes plus	0.31	0.11	0.06
13	Totals	100.00	100.00	100.00

Source* = CEE (Center for energy & economics).

Table (2) Top 20 flaring countries**

Rank 2004	Country	Reported Flaring , (bcm)2004
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	EquatorialGuinea	3.6
10	Indonesia	3.5
11	USA	2.8
12	Kazkhstan	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
	Total Top 20	107.5

Source: GGFR (The Global Gas Flaring).**

Expermental work:

It has been taking samples of gas from both fields (Southern&Northern Jambour) in different times and so for comparison between gas fields components where we took samples of gas from the Southern Jambour field line 16", 20" dated 01/06/2015, and the sample of the gas from the North Jambour field (Contactor Outlet) send to North Gas Company dated 02/06/2015, and as we take the sample of gas flares in the Southern Jambour field on 02.06.2015 and to identify the components, then we took the three samples for months (03.08.12 / 2013) of field Jambour South as well as three samples for months (08.04.12 / 2013) of field Jambour North, then we took samples of gas during the stages of production of the field Northern Jambouron on 13/05/2014 in order to identify the changes in the proportions of gas

components over time through an analysis of the samples using the instrument (Gas Chromatography) .

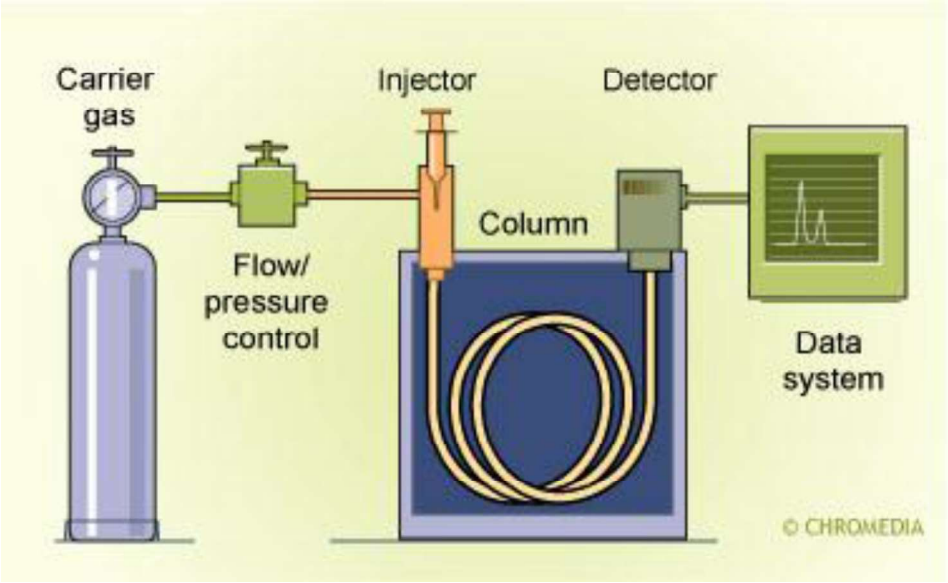

Fig.(2) Gas Chromatography Instrument

Results and discussion:

Table (3) shows the percentages of the components of gas in the Southern Jambour field notes that methane is a higher amount than other components, and be free of gas hydrogen sulfide and this is gas produced from the Southern Jambour field sweet gas with a small amount of carbon dioxide.

Table (3) The Southern Jambour Gas analysis on 01/06/2015

Gas Chromatography	By VARIAN CP-3800 GC INSTRUMENT
Date of Sampling	01/06/2015
Date of Testing	02/06/2015
Source of Sample	Ja- S

Sampling Point	16" line	20" line
Sample Temp. (C°)	35	40
Sample Press. (psig)	560	560
Result of Analysis		
Component	Mole%	Mole%
N_2	0.00	0.00
C_1	83.18	81.77
CO_2	0.08	0.09
C_2	9.30	8.83
H_2S	0.00	0.00
C_3	3.98	3.73
iC_4	0.55	0.55
nC_4	1.43	1.50
iC_5	0.46	0.73
nC_5	0.67	0.89
C_{6+}	0.35	1.91
Total	100.00	100.00
Ton LPG / MMSCF	3.47	3.39
M_{wt}	20.20	21.46
Density (gm/cc)	0.000853	0.000907
SP.Gr	0.6974	0.7411
Net C. V. (BTU/ft^3)	1121.74	1184.36
Gross C. V. (BTU/ft^3)	1237.90	1305.04

Table (4) shows the results of the analysis of the gas field in the Northern Jambour notes that the amount of methane gas constitutes the highest proportion of the other components with a small percentage of hydrogen sulfide gas where they are disposed of through the stripping units.

Table (4) The Northern Jambour gas analysis dated 02/06/2015

Gas Chromatography	**By VARIAN CP-3800 GC INSTRUMENT**
Date of Sampling	02/06/2015
Date of Testing	03/06/2015
Source of Sample	Ja-N
Sampling Point	Contactor Outlet A line/NGC)(
Sample Temp. (C°)	26

Sample Press. (psig)	31.5
Result of Analysis	
Component	Mole%
N_2	0.00
C_1	75.36
CO_2	6.42
C_2	8.93
H_2S	4.52
C_3	2.77
iC_4	0.29
nC_4	0.73
iC_5	0.26
nC_5	0.25
C_{6+}	0.47
Total	100.00
Ton LPG / MMSCF	2.17
M_{wt}	21.73
Density (gm/cc)	0.000918
SP.Gr	0.7502
Net C. V. (BTU/ft^3)	996.62
Gross C. V. (BTU/ft^3)	1100.17

Table (5) Shows of the rates of change of the gaseous components in the Southern Jambour field for months (03.08.12 / 2013) in accordance with the laboratory analysis .

Table (5) Gas components of the Southern field

Gas Chromatography	**By VARIAN CP-3800 GC INSTRUMENT**		
Date of Sampling	06/03/2013	26/08/2013	29/12/2013
Date of Testing	07/03/2013	27/08/2013	30/12/2013
Source of Sample	Ja- S		
Sampling Point	Contactor Outlet line 16" (Train A)		
Sample Temp. (C°)	70	-----	70
Sample Press. (psig)	590	490	545
Result of Analysis			
Component	Mole%	Mole%	Mole%
N_2	0.00	0.00	0.00

C_1	78.64	83.05	79.08
CO_2	0.05	0.07	0.10
C_2	9.46	9.19	9.81
H_2S	0.00	0.00	0.00
C_3	5.22	3.98	4.70
iC_4	0.82	0.57	0.74
nC_4	2.16	1.47	2.06
iC_5	1.92	0.52	0.93
nC_5	1.33	0.64	1.08
C_{6+}	0.40	0.51	1.50
Total	100.00	100.00	100.00
Ton LPG / MMSCF	4.82	3.52	4.42
M_{wt}	22.20	20.33	22.12
Density (gm/cc)	0.000938	0.000859	0.000934
SP.Gr	0.7667	0.7021	0.7639
Net C. V. (BTU/ft^3)	1223.83	1128.77	1218.30
Gross C. V. (BTU/ft^3)	1347.42	1245.45	1341.45

Table (6) Shows rates of change of the gaseous components in the NorthernJambour field for months (08.04.12 / 2013) in accordance with the laboratory analysis .

Table (6) Analysis of the Northern Jambour field for months (08.04.12 / 2013)

Gas Chromatography	**By VARIAN CP-3800 GC INSTRUMENT**		
Date of Sampling	29/04/2013	04/08/2013	03/12/2013
Date of Testing	29/04/2013	05/08/2013	04/12/2013
Source of Sample	Ja-N		
Sampling Point	Contactor Outlet (A6 line/NGC)		
Sample Temp. (C°)	21	33	22.9
Sample Press. (psig)	30	29	29.65
Result of Analysis			
Component	Mole%	Mole%	Mole%
N_2	0.00	0.00	0.00
C_1	74.31	70.10	72.56
CO_2	6.94	6.66	6.90
C_2	10.95	11.06	10.70
H_2S	0.45	4.78	4.35
C_3	4.56	4.10	3.43
iC_4	0.52	0.60	0.35
nC_4	1.18	1.40	0.93

iC_5	0.35	0.45	0.24
nC_5	0.41	0.55	0.31
C_{6+}	0.33	0.30	0.23
Total	100.00	100.00	100.00
Ton LPG / MMSCF	3.58	3.55	2.70
M_{wt}	22.25	23.08	22.23
Density (gm/cc)	0.000940	0.000975	0.000939
SP.Gr	0.7683	0.7969	0.7675
Net C. V. (BTU/ft^3)	1061.01	1057.39	1013.43
Gross C. V. (BTU/ft^3)	1170.21	1165.18	1118.07

Table (7) shows the results of gas analysis at different stages of production in the Northern Jambour field and note that the amount of hydrogen sulfide gas is a few while methane highest amount from the other components .

Table (7) The Northern Jambour gas field analysis on 14/05/2014

Gas Chromatography	**By VARIAN CP-3800 GC INSTRUMENT**				
Date of Sampling	13/05/2014				
Date of Testing	14/05/2014				
Source of Sample	AB-7 Compressor Station (Ja-N)				
Sampling Point	1st Stage Comp.	2nd Stage Comp.	1st Stage Deg.	Cont. Outlet	Fuel Gas
Sample Temp. (C°)	39.86	46.5	36.1	42	28
Sample Press. (psig)	3.36	11.2	31	31	30
Result of Analysis					
Component	Mole%	Mole%	Mole%	Mole%	Mole%
N_2	0.00	0.00	0.00	0.00	0.00
C_1	28.85	54.51	72.09	68.00	84.55
CO_2	6.96	6.21	6.59	6.28	0.08
C_2	22.42	17.57	9.30	10.52	8.77
H_2S	18.45	6.27	6.41	6.80	0.00
C_3	12.43	8.15	3.10	4.01	3.28
iC_4	1.68	1.04	0.34	0.49	0.44
nC_4	4.16	2.58	0.94	1.28	1.14

iC_5	1.34	0.83	0.33	0.49	0.34
nC_5	1.44	0.91	0.38	0.58	0.44
C_{6+}	2.27	1.93	0.52	1.55	0.96
Total	100.00	100.00	100.00	100	100
Ton LPG / MMSCF	10.61	6.81	2.52	3.34	2.83
M_{wt}	33.56	27.51	22.52	24.06	19.99
Density (gm/cc)	0.001417	0.001162	0.000951	0.001016	0.000844
SP.Gr	1.1584	0.9499	0.7774	0.8306	0.6903
Net C. V. (BTU/ft^3)	1419.46	1275.48	1010.04	1090.39	1110.60
Gross C. V. (BTU/ft^3)	1549.33	1398.73	1113.95	1200.10	1225.95

Table (8) shows the amount of the components of flaring gas in Southern Jambour field and is a methane gas 73% from the other components and note that the amount of propane is 6.87 %, which is a high percentage if we compare it withit amount of produced gas from the Southern Jambour field.

Table (8) The percentages of components of flaring gas in the Southern Jambour

Gas Chromatography	**By VARIAN CP-3800 GC INSTRUMENT**
Date of Sampling	02/06/2015
Date of Testing	03/06/2015
Source of Sample	Ja-S
Sampling Point	Flare Line
Sample Temp. (C°)	------
Sample Press. (psig)	60
Result of Analysis	
Component	Mole%
N_2	0.00
C_1	73.37
CO_2	0.08
C_2	11.53
H_2S	0.00
C_3	6.87
iC_4	1.32
nC_4	3.39
iC_5	1.18
nC_5	1.62

C_{6+}	0.64
Total	100.00
Ton LPG / MMSCF	6.89
M_{wt}	23.61
Density (gm/cc)	0.000997
SP.Gr	0.8152
Net C. V. (BTU/ft^3)	1295.98
Gross C. V. (BTU/ft^3)	1424.83

The figure (1) shows results of the analysis of flaring gas of Southern Jambour oil field is clear to us that the propane gas and Normal butane and isobutane high amount compared with the gas produced from the field , and as shown in Figures (1-3).

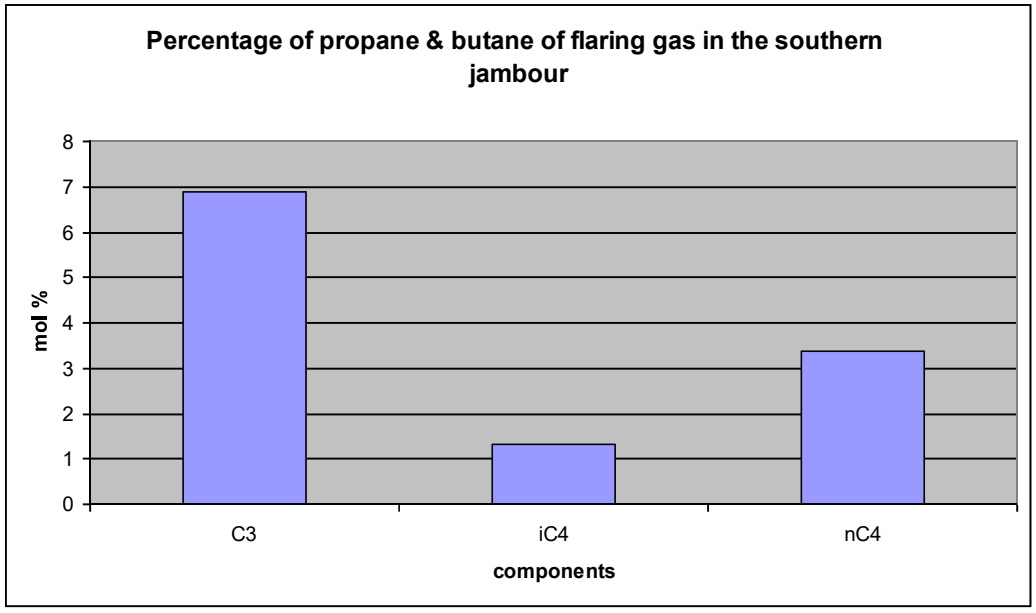

Fig. (2) Percentage of propane & butane of flaring gas in the Southern Jambour

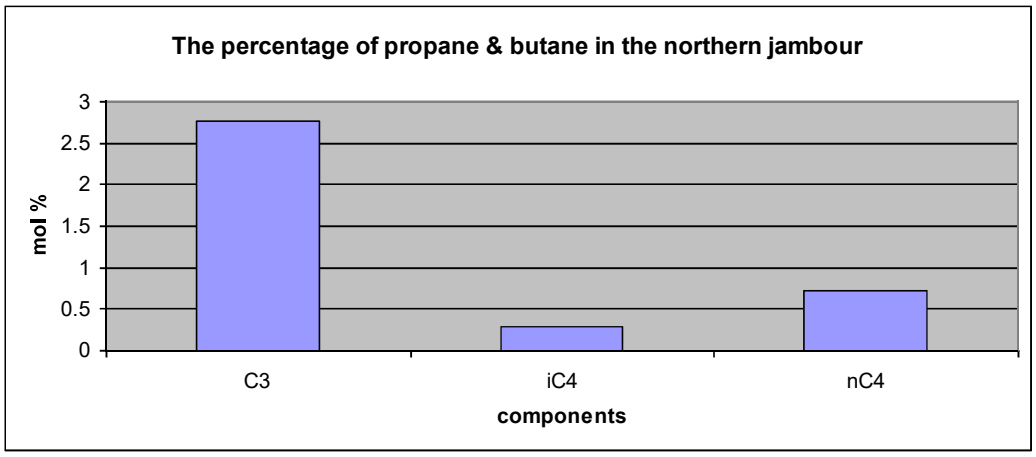

Fig. (3) Percentage of propane & butane in the Northern Jambour

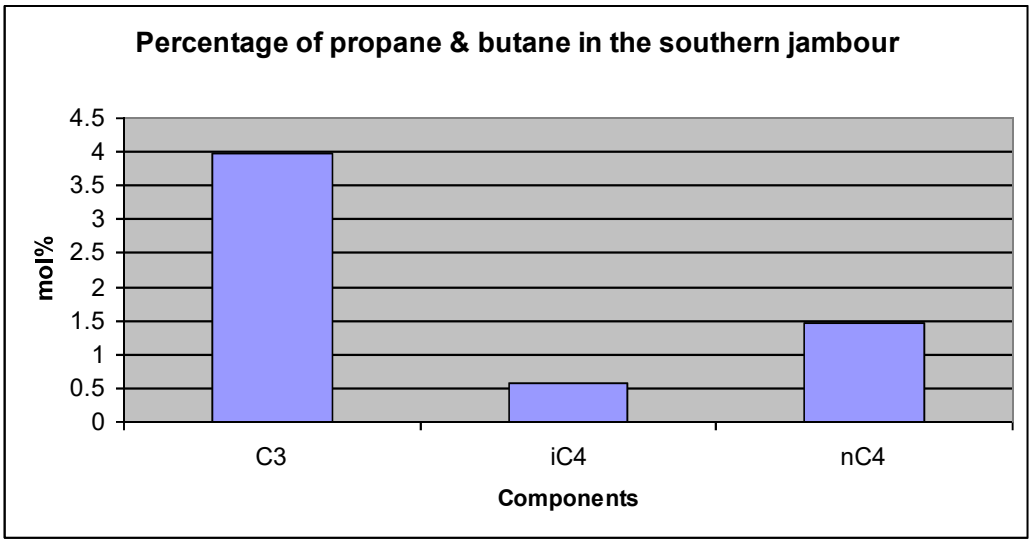

Fig. (4) Percentage of propane & butane in the Southern Jambour

From these equations can find a mass of each component of the gas components as in the accompanying table [13].

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

Where X= molar fractio

n_i=The number of moles of gaseous component ،

n= The total number of moles of gas

$\bar{X} = m_i/m$ ---------- (2)

Where $\bar{X}$=mass fraction, mi=Mass gaseous component,

m=the total mass of gases.

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

Where Mi = Molecular weight of the gaseous component.

Table (9) Gaseous components according to the weighted fracture of the associated gas north and south fields

i)component(	Symbol	M_i	n_i)(NorthernJambour	X_i NorthernJambour	n_i)(SouthernJambour	X_i SouthernJambour
Nitrogen	N_2	28	0.00	0.00	0.00	0.00
Methane	C_1	16.04	79.5	58.6471	81.16	62.3202
Carbon Dioxide	CO_2	44	0.14	O.2833	.220	0.4634
Ethane	C_2	30.07	9.24	12.7785	9.46	13.6178
Sulfur Hydrideox	H_2S	32	0.00	0.00	0.00	0.00
Proane	C_3	44.09	5.56	11.2743	4.72	9.9624
i-Butane	i-C_4	58.12	0.89	2.379	0.81	2.2537
n-Butane	n-C_4	58.12	2.22	5.9341	2.01	5.5925
i-Pentane	i-C_5	72.15	0.72	2.3892	0.61	2.1069
n-Pentane	n-C_5	72.15	0.84	2.7873	0.72	2.4869
Hexane	C_6	86.17	0.89	3.5271	0.29	1.1963
Total	----	----	100	100.0	100	100

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 / cc) , v_{gas} = the volume of gas (Cm3)

.

(1mmscf) of gas equivalent to (25 ton) which means that the burning of associated gas rate in Southern Jambour fields equivalent (25 ton / day) , and this is not constant and may increase up to (4 MMSCF /day) (according to company sources).

For example, the amount of associated gas that burns (flaring gas) in khbaz oil field is 7 mmscf / day .[12]

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 [13]:

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

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% [14].

m°_{gas}= (12.5 * 1000) Kg/day * 1day /(24*60*60) = 0.14 Kg/sec ,

$Q^{\circ} = m^{\circ}_{gas} * Q_{HV}$, Q°= 0.14* 40 MJ/Kg =5.6 MJ/sec ,

$Power = Q^{\circ} * \eta_{th}$= 5.6MJ/sec * 0.35 = 1.96 MW .

This means that if the use of flaring gas correct we will get the (1.96 MW) to the electricity sector.

And if we know that Southern Jambour field 's gas production at the present time a (130 MMSCF) (3250 ton / day) , and methane constitutes up to 60 % which is equivalent to (1950 ton / day) and technical specifications for types of gas turbines used in the production of electric energy shows that the turbine (GT13E2) , which produces the amount of electrical energy (165 MW) needs a quantity of gas of (850 ton / day) is equivalent to (36 mmscf / day) , if the half production of the Southern field Jambour -free (H2S)- it is possible to run two of the turbine (GT13E2) and get a(298 MW) .

Conclusions:

1- We hav not Technology for liquefaction and storage of methane gas , which constitutes 80% of the volume of gas production .

2- The possibility of using the Southern Jambour production field in the production of electrical energy due to free of hydrogen sulfide gas.

3- Through calculations show that a(1 mmscf) of gas equivalent to (25 tons / day) , and if the quantity burned daily in the Southern Jambour field Approximate (1-4 mmscf)If we take value at least (1 mmscf) which has a methane gas ratio 73.37 % by volume,50 % By weight which can be used in the production of electrical energy and in other activities .

Recommendations:

1- Gas injection in oil wells to stabilize the pressure wells and improve oil production process.

2- Take advantage of the flaring gas in SouthernJambour through pressed to production lines (20 " , 16 ") due to free of hydrogen sulfide gas , although the quantity of a few (1-4 mmscf / day) .

3- Building a cold stripping unitsin the Northern Jambour and supplying sweet gas from the Southern Jambour due to close the distance between them.

Nomenclature:

Mmscf = million standard cubic foot

Tcf = trillion cubic feet

Scf = Standard Cubic Feet

VOC_S = volatile organic compounds

EIA = the Energy Information Agency

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