Analysis and National Solution for CO₂ Gas in Missan Oil Field

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Abstract. A site study on associated gas from six oil fields of the Missan Oil Company (MOC) was carried out during 2018. The studied zone is located in the southern part of Iraq. The main objective in the present work was to conduct a complete analysis of the associated gas from the oil fields of the MOC. Another objective was to propose theoretically an appropriate method of capturing carbon dioxide to make the natural gas compliant with the U.S. specifications for the pipeline of natural gas transportation. Gas quantities were measured from each oil field as well as component analysis to determine the percentage of carbon dioxide in the gas. The study revealed that CO₂ concentration in the oil fields was slightly increased with time. Moreover, the results showed that the separation technique of CO₂ from natural gas was the absorption method in the field of AMARA, while the membrane-separation method was preferred in Al NOOR field as well as BUS2 station, while the two methods are competing in the BAZRGAN field (BUS1, BUS3 and BUN stations).

Keywords: Associated gas; Natural gas transportation; CO₂ capture

1. Introduction

1.1 Overview.

Raw natural gas varies substantially in composition from source to source. Methane is always the major component, typically 75%-90% of the total. However, natural gas also contains significant amounts of ethane, some propane and butane, and 1%-3% of higher molecular weight hydrocarbons. In addition, natural gas contains undesirable impurities, such as water, carbon dioxide, nitrogen, and hydrogen sulfide, and Hg [1]. The presence of CO₂ in natural gas reduces the heating value of the gas in power plants, and due to its acidic character, causes corrosion in equipment and pipelines. On the other hand, the separation of CO₂ from the gas stream is an essential step in some industrial processes. Moreover, it is needed for technical, economic, and environmental reasons. In Liquefied Natural Gas (LNG) industry, CO₂ must be separated to prevent several problems such as a freezing problem in low-temperature chillers, corrosion in the process equipment, reduction in the caloric value of gas, and a decrease in pipeline capacity. This makes the removal of CO₂ from natural gas of crucial importance [2][3]. The percentage of carbon dioxide in natural gas can vary from 4 to 50%, depending on the source of the gas or oil well. Before the transportation of NG, it must be pre-processed to meet the typical pipeline specification of less than 2 % CO₂, and for the liquefaction process, the gas should have a carbon dioxide content of fewer than 50 ppmv[2][4][5]. Table 1 lists the typical composition of natural gas in transmission pipelines as well as gas supplied to liquefaction plants, based on specifications approved worldwide.
Table 1: Specifications Limits for Natural Gas Delivery [6].

| Major Components          | Feed to Pipeline Gas | Feed to LNG Plant |
|---------------------------|----------------------|-------------------|
|                           | Minimum              | Maximum           |
| Methane                   | 75 Mol%              | None              |
| Ethane                    | None                 | 10 Mol%           |
| Propane                   | None                 | 5 Mol%            |
| Butanes                   | None                 | 2 Mol%            |
| Pentanes and heavier      | None                 | 0.5 Mol%          |
| Nitrogen and other inert  | None                 | 3 Mol%            |
| Carbon dioxide            | None                 | 2 Mol%            |
| Hydrogen sulfide          | 6                    | 7 mg/m3           |
| Total sulfur              | 115                  | 460 mg/m3         |
| Water vapor               | 60                   | 110 mg/m3         |
| Oxygen                    | None                 | 1 Mol%            |

Several techniques are employed for Pathway CO\(_2\) Capture (PCC). Some of these include absorption, membrane, adsorption, and cryogenic separation. In terms of the suitability of the CO\(_2\) capture systems, each separation technology has different limitations and applications. The selection of technology for a given capture application depends on many factors, i.e., the partial pressure of CO\(_2\) in the gas stream, the extent of CO\(_2\) recovery required, regeneration of the solvent, sensitivity to impurities, such as acid gases, particulates, purity of the desired CO\(_2\) product, capital and operating costs of the process, the cost of additives necessary to overcome fouling and corrosion and where applicable, the environmental impacts [7][8][9][10].

1.2 Natural Gas in Iraq.

Iraq is the 12th in terms of natural gas reserves in the world, and proven reserves amount to about 3729 billion cubic meters [11]. The associated gas ratio is about 83%, while the non-associated gas is 17% of the gas produced. Southern region production represents the highest proportion of daily gas production, reaching 71%. The northern region 16%, while the central and western regions account for 9% and 4% respectively. Iraq flared 629 Billion cf of natural gas, ranking as the second-largest source country of flared gas in the world behind Russia [12][13][14]. Most natural gas produced is not used because of the lack of facilities to process it. Burning gas in this way is a major environmental problem, as this process causes the emission of nearly 400 million tons of carbon dioxide globally. It is expected that the financial losses of Iraq to about $16 billion annually in 2016 [15]. On the other hand, Iraq began importing natural gas from Iran in June 2017 to fuel electric power plants near Baghdad, including the Al-Besmaya, Al-Quds, Al-Mansuriyah, and Al-Sadr stations. Annual natural gas imported averaged 4,100 million cubic meter in 2018. However, it is likely that these quantities will rise because of the constant increase in demand for electricity[12][16]. The first steps to invest gas are to be complied within the API standard limits for gas specifications in pipelines. This is achieved by removing existing impurities; the most important ones are carbon dioxide and hydrogen sulfide. The main objective in the present work is to conduct a complete analysis of the associated gas from the oil fields of the MOC. Another objective is to propose theoretically an appropriate method of capturing carbon dioxide to make the natural gas compliant with the U.S. (API) specifications for the pipeline of natural gas transportation.
2. Methods
The study area was selected based on a report issued by the Federal Office of Financial Supervision (FOFS) which stated that most natural gas produced from the fields of Maysan Oil Company (MOC) is burned and non-invested [17]. The present study was conducted in cooperation with MOC where the quantities of natural gas have been determined in each field as well as the percentage of CO\textsubscript{2} in each gas station. The natural gas produced from Maysan oilfields during the last three months of 2018 is estimated as 333.51 million standard cubic feet per day. This amount of associated gas is produced from six fields containing thirty-two stages of separation. Figure 1 represents a google map of the study zone.

| Site        | Coordinates                      | Distance from the Iraqi-Iranian Border |
|-------------|----------------------------------|---------------------------------------|
| BUS2        | 32°05'50.7"N 47°25'43.4"E        | -                                     |
| BUS3        | 32°03'45.7"N 47°26'48.2"E        | -                                     |
| Al NOOR     | 31°56'16.2"N 47°16'18.4"E        | -                                     |
| AMARA       | 31°47'33.6"N 47°03'26.4"E        | -                                     |
| FQS         | 32°06'35.4"N 47°33'01.2"E        | 980.47 m                              |
| FQN         | 32°10'49.2"N 47°31'13.4"E        | 1.30 km                               |
| Abu Gharb   | 32°21'06.5"N 47°25'51.1"E        | 409.9 m                               |
| Al-Halafiyya| 31°40'29.8"N 47°25'56.5"E        | -                                     |

Figure 1. Google Map of the Study Zone

Several factors should be taken into account for the selection of an appropriate separation process. Two of the most important factors are the percentage of carbon dioxide in natural gas and the gas flow rate. Baker and Lokhandwala presented a plot illustrating the effect of gas flow rate and carbon dioxide concentration in the natural gas on the choice of carbon dioxide removal technology (see Figure 2) [1]. Figure 2 was used as a guide for the process selection. It is worth noting that this figure should be used with care, as site-specific issues can produce very different results. In the present paper, the determination of associated gas ingredients in the Missan oil fields was carried out. The gas fields with high CO\textsubscript{2} levels were identified. Then, a suitable separation method was suggested to remove carbon dioxide to meet the standards of natural gas pipelines so that the natural gas can be safely transferred for exportation.
3. Analysis method

Gas Chromatography (Model: Agilent Technologies 7890A GC System) is shown in Figure 3. It was used to analyze samples taken from each stage in the six oil fields. The gas sample is taken after the multi-stage separation process from crude oil. The gas samples were analyzed by the GC system through the following steps.

1. The sample is taken from inside the field, and the temperature, pressure, and wells operating in the gas separation stations are recorded. A 500 mL cylinder is used, and the cylinder can withstand pressure up to 6 MPa and temperature limits 40 – 100.
2. The person who takes the sample records the information such as sample code, the point of taking the sample, the date, temperature, and pressure.
3. The sample cylinder is placed in the laboratory oven for heating to a temperature equal to that of the separation station.
4. The GC is prepared for injection by operating for a period of time at high temperature (the highest temperature endured by the column of the GC). Preheating removes and cleans the column from the residue of the previous sample, where it is ready for testing.
5. The sample information is entered into the GC, such as temperature, pressure, working wells, and date. After that, the cylinder is connected to the GC device, wait until the temperature drops to 60, and wait for 30 seconds before the gas injection to reach the state of stability inside the column.
6. The analysis process begins within the device and lasts for 35 minutes, after which the device gives a full report on the model and determines the percentage of the compounds in the model.

![Figure 2. Schematic Plot Illustrating the Effect of Gas Flow Rate and Carbon Dioxide Concentration in the Gas on the Choice of Carbon Dioxide Removal Technology [1]](image-url)
Fig 3: Gas Chromatograph (Agilent Technologies 7890A GC System)

The column used in the GC for natural gas analysis is the model (Agilent HP-5 GC Column), and the specifications and dimensions of this column are shown in Table 2.

Table 2: Specifications of Agilent HP-5 GC Column.

| Column Family        | HP-5       |
|----------------------|------------|
| Type                 | 5" CAGE   |
| ID                   | 0.32 mm   |
| Length               | 30 m      |
| TEMP LIMIT (Celsius) | -60 to 325/350 |
| Film Thickness       | 0.25 μm   |

4. Result and discussion

4.1 Natural gas analysis
The percentage of gas produced from each field of MOC as well as the average percentage of carbon dioxide in natural gas from each field shown in Figures 4 and 5.

Gas analysis and gas flow rate from six oil fields of MOC containing 32 stages to separate associated gas during the four seasons of 2018 are cited in Appendix A.

4.2 Selection of appropriate process
Average results of the quantities of gas produced from each field with average carbon dioxide ratios in the four seasons were listed in Table 3. These values are adopted in Figure 6.
Figure 4: The Percentage of Each Field of Total Gas Production.

Figure 5: Average Percentage of Carbon Dioxide in Missan Oil Fields.

Table 3. Quantities of Gas Produced and Average CO\textsubscript{2} Percentage.

| Field       | Quantity MMscfd (Average) | CO\textsubscript{2} Mole % (Average) | COLOR |
|-------------|--------------------------|-------------------------------------|-------|
| BAZRGAN     |                          |                                     |       |
| BUS 1       | 11.155                   | 5.38                                | ●     |
| BUS 2       | 7.73                     | 5.1                                 | ●     |
| BUS 3       | 10.565                   | 5.01                                | ●     |
| BUN         | 20.1                     | 6.00456                             | ●     |
| Al NOOR     | Quantity MMscfd (Average) | CO\textsubscript{2} Mole % (Average) | COLOR |
| NOOR        | 5.0075                   | 5.42029                             | ●     |
| AMARA       | Quantity MMscfd (Average) | CO\textsubscript{2} Mole % (Average) | COLOR |
| AMARA       | 13.35                    | 3.9888                              | ●     |

Figure 6. Schematic Plot Illustrating the Choice of CO\textsubscript{2} Removal Technology.
It is observed from Figure 6, that the use of the membrane separation method is favored in the NOOR field, while the absorption technique is the preferred method in the field of AMARA. Furthermore, in the BUS1, BUS2, BUS3, and BUN stations, the two methods are competing. However, other factors determining the best technology for the separation of carbon dioxide from natural gas may also be taken into account. The results obtained in this study represent a preliminary step in the methodology for selecting the optimal separation method of carbon dioxide, which is more than 2% mol, in the fields of MOC. However, to determine the best option of CO$_2$ separation, other factors contribute to this issue which is the most influential factor at the level of Iraq, such as the required electrical energy, construction cost, operational expertise, environmental determinants. Even though the conventional technologies are still in operation for the removal of the CO$_2$ from the natural gas in MOC fields, the outcomes of the present study were based on real lab analysis of producing oil fields in the MOC.

5. Conclusion

About 95% of the natural gas produced from the oil fields in Iraq is non-invested. In the present work, a detailed and long-term analysis of natural gas from six oil fields of the MOC in the southern part of Iraq was conducted for a complete analysis of associated gas, and introduced a theoretical proposition for selection of separation method of CO$_2$ from associated gas. Outcomes of the present study revealed CO$_2$ concentration in the oil fields was slightly increased with time. Moreover, the proposed separation technique of CO$_2$ from natural gas was the absorption method in the field of AMARA, while the membrane-separation method was preferred in Al NOOR field as well as BUS2 station, while the two methods are competing in the BAZRGAN field (BUS1, BUS3 and BUN stations). However, other factors (e.g., the required electrical energy, the cost of construction, operational expertise, and environmental determinants) in determining the best technology for the separation of carbon dioxide from natural gas may also be taken into account.

6. References

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## Appendix A

### Table A1: Gas Analysis and Quantities Measured in MOC Oil Fields During Season 1 (2018)

| Oil Field     | Site          | Data        | Quantity MMscfd | CO₂ Mole % | H₂S Mole % | CH₄ Mole % | C₂H₆ Mole % | C₃H₈ Mole % |
|---------------|---------------|-------------|-----------------|------------|------------|------------|-------------|-------------|
| **Bazrgan Field** | BUS 1         | 23/1/2018   | 8.69            | 5.476597   | 1.9        | 64.348602  | 14.832621   | 7.416159    |
|               | BUS 2 - Stage 1 | 23/1/2018   | 6.8             | 5.281357   | 1.6        | 66.003421  | 14.950977   | 7.172751    |
|               | BUS 2 - Stage 2 | 16/1/2018   | 6.8             | 5.222535   | 1.9        | 65.594256  | 14.934791   | 7.201835    |
|               | BUS 3 - Stage 1 | 16/1/2018   | 10.88           | 5.096341   | 1.4        | 64.527246  | 15.214648   | 7.79954     |
|               | BUS 3 - Stage 2 | 16/1/2018   | 10.88           | 5.302812   | 1.6        | 65.131028  | 15.125478   | 7.45287     |
|               | BUN - Stage 1   | 30/1/2018   | 18.8            | 5.835559   | 1.8        | 63.255882  | 14.896341   | 7.940473    |
|               | BUN - Stage 2   | 30/1/2018   | 18.8            | 6.277575   | 3.2        | 65.606357  | 21.043968   | 13.532826   |
| **Al NOOR Field** | NOOR - Stage 1 | 6/2/2018    | 4.94            | 4.845724   | 0.7        | 68.015104  | 14.956542   | 7.041474    |
| **AMARA Field** | AMARA - Stage 1 | 13/2/2018   | 13.73           | 3.891754   | 0.3        | 69.567152  | 14.983301   | 6.776439    |
|               | AMARA - Stage 2 | 14/2/2018   | 13.73           | 4.246436   | 0.2        | 58.332905  | 20.139597   | 10.156027   |
|               | FQ5 - Stage 1   | 27/2/2018   | 15.43           | 2.321953   | 0.2        | 67.096578  | 16.119095   | 8.063686    |
|               | FQ5 - Stage 2   | 27/2/2018   | 15.43           | 2.664995   | 1          | 48.914401  | 24.090841   | 14.076111   |
|               | FQN - Stage 1   | 27/2/2018   | 9.01            | 1.217782   | 0.2        | 65.628927  | 16.375595   | 8.765412    |
| **Al-Fakkah Field** | AGS 1 - Stage 1 | 6/3/2018    | 16.22           | 0.513662   | 0          | 67.688983  | 16.414634   | 8.393893    |
|               | AGS 1 - Stage 2 | 6/3/2018    | 16.22           | 0.598192   | 0          | 60.097407  | 19.972048   | 10.978924   |
|               | AGS 2 - Stage 1 | 6/3/2018    | 5.8             | 0.319945   | 0          | 68.567378  | 16.579975   | 8.246279    |
|               | AGS 2 - Stage 2 | 6/3/2018    | 5.8             | #           | #          | #          | #           | #           |
|               | AGN - Stage 1   | 6/3/2018    | 0.84            | 0.13549    | 0.002      | 71.582443  | 16.357958   | 7.133923    |
| **Abu Gharb Field** | CPF11 - Stage A | 26/3/2018   | 125.9           | 1.879776   | 0.852523   | 71.124982  | 14.184598   | 6.587701    |
|               | CPF11 - Stage B | 26/3/2018   | 125.9           | 1.935045   | 0.183697   | 71.40513   | 14.065813   | 6.896694    |
|               | CPF11 - Stage C | 26/3/2018   | 125.9           | 2.673242   | 0.173350   | 70.755356  | 13.626819   | 6.80573     |
|               | CPF12 - Stage A | 26/3/2018   | 125.9           | 1.498877   | 0          | 21.120211  | 20.955347   | 24.15246    |
|               | CPF12 - Stage B | 26/3/2018   | 125.9           | 1.571868   | 0          | 28.125238  | 19.947893   | 21.331716   |
| **Al-Halafiya** | CPF12 - Stage C | 26/3/2018   | 77.99           | 1.00011    | 0.163993   | 12.430214  | 13.127145   | 19.852321   |
|               | CPF21 - Stage A | 19/3/2018   | 77.99           | 3.037355   | 0.439730   | 66.125472  | 16.44534   | 7.78995     |
|               | CPF21 - Stage B | 19/3/2018   | 77.99           | 3.183121   | 0          | 68.044516  | 16.323107   | 7.511017    |
|               | CPF21 - Stage C | 19/3/2018   | 77.99           | 3.624633   | 0.46938    | 69.7703528  | 14.93132   | 6.775541    |
|               | CPF22 - Stage A | 19/3/2018   | 77.99           | 2.150057   | 0.29226    | 25.641823  | 22.146291   | 23.792275   |
|               | CPF22 - Stage B | 19/3/2018   | 77.99           | 1.886081   | 0.260974   | 17.27222   | 19.116316   | 22.810488   |