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Natural Gas Properties Analysis of Bangladesh: A Case Study of Fenchuganj Gas Field

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Abstract: *Fenchuganj gas field is located at Surma Basin and 40 km south of Sylhet town. This field is operated by Bangladesh Petroleum Exploration and Production Company Limited (BAPEX). Gas properties analysis is essential for gas production designing, gas processing, gas transportation and gas handling systems. This study covers the mathematical and graphical calculation to analyze several properties of gas such as molecular weight, gas gravity, gas compressibility factor, gas formation volume factor, gas expansion factor, gas density and gas viscosity of Fenchuganj gas well, FG-2 and FG-3. The gas molecular weight is 16.2979 and 16.395 respectively for FG-2 and FG-3. Specific gas gravity is found 0.5625 for FG-2 and 0.5659 for FG-3. The gas compressibility factor is also determined for FG-2 which is 0.84 for Upper Gas Sand(UGS), 0.91 for Middle Gas Sand(MGS) and 0.92 for Lower Gas Sand(LGS). Similarly for FG-3, gas compressibility is 0.83 for New Gas Sand (NGS-ii) and 0.84 for Upper Gas Sand (UGS). Gas formation volume factor, gas expansion factor and gas density for FG-2 range from 4.73×10^{-3} to 4.01×10^{-3} res.ft^3 /scf, 211.416 to 249.376 and 9.18 to 10.70 lb/ft^3 respectively. Similarly for FG-3, it ranges from 4.78×10^{-3} to 4.76×10^{-3} res.ft^3 /scf, 209.205 to 210.084 and 9.13 to 9.23 lb/ft^3 respectively. The viscosity of FG-2 ranges from 0.01872 cp to 0.02108cp and for FG-3 it ranges from 0.01805 cp to 0.01832cp. The corresponding pseudo-critical temperature for FG-2 is 349 $^\circ$R and 350 $^\circ$R for FG-3. The pseudo-critical pressure for FG -2 is 670 psia and 669.9 psia for FG -3. The FG-2 and FG-3 both contain methane 0.97(mole fraction) or 97% and 0.98 (mole fraction) or 98%, the presence of hydrogen sulfide is zero. So Fenchuganj gas reservoir is sweet gas reservoir.*

Keywords: *Specific Gravity, Compressibility, Formation volume factor, Viscosity, Sweet gas Reservoir.*

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I. Introduction

Bangladesh is the greatest delta land in the world and it is beside the Bay of Bengal. Due to the stratigraphic and geological respect, Bangladesh has occupied several natural resources. The main resource is natural gas. Besides, the country has coal, hard rock, peat, heavy minerals in the beach, glass sand, calcium carbonate and some others valuable minerals. There are 27 discovered gas field at present in the country. Most of the gas fields are in the fold belt zone and two are in the off shore. Natural gas is composed of mainly methane. Beside some other light hydrocarbons like Ethane, Propane, Butane, Pentane, Hexane, Heptane and trace elements like hydrogen sulphide, carbon dioxide, nitrogen, argon are found in natural gas. Natural gas has several specific properties which characterize the gas fields as well as gas qualities. Natural gas properties are essentials for designing gas production, processing, transportation and handling systems [1]. This research covers the gas properties such as molecular weight, gas gravity, gas compressibility factor, gas formation volume factor, gas expansion factor, gas density and gas viscosity of Fenchuganj gas well FG-2 and FG-3. These physical properties are crucial for gas reservoir engineering problem solving. These properties can be measured either laboratory test or mathematical calculation from gas elemental compositions [2].

II. Study Area and Geology

Fenchuganj gas field is located in southern part of Bangladesh and in Sylhet division (Figure-1). It lies in Surma basin and characterized in water drive gas field [3]. It is in Fenchuganj upazila and about 40 km south-east of Sylhet town. It is bounded by Longitude E 91º 53' – 92º and Latitude N 24º 30' – 24º 37' and is 30 km long and 8 km wide [4].Fenchuganj gas field was discovered by Petrobangla in 1988[5]. The lithological sequences encountered in the area ranges from Oligocene to Pliocene age. The gas bearing sands of the structure are within Lower Bokabil to Upper Bhuban Formations of the Late Miocene age [4]. Miocene sediments like alternating gray to dark gray clay and very fine to fine grained sandstone is found in the reservoir [6].

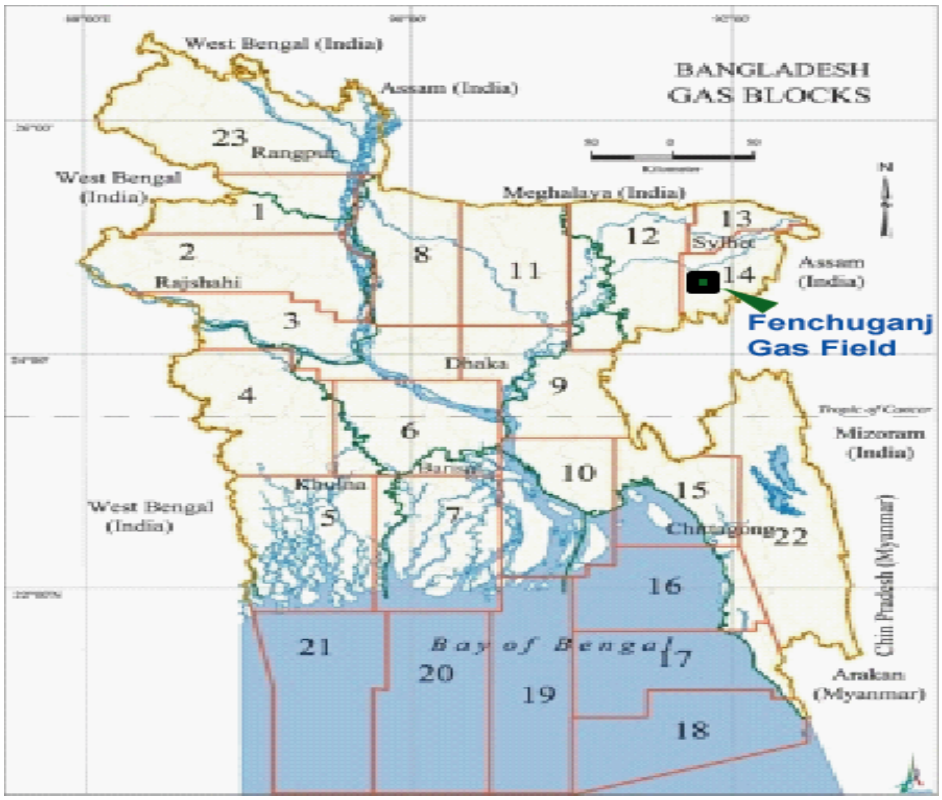


Figure-1: Gas block map of Bangladesh showing Fenchuganj gas field (Source: modified from Banglapedia)

III. Materials and Methodology

Necessary data for the study

The input data for the study is secondary data. The gas component composition for the FG-2 and FG-3 and the several gas sand layer pressure and temperature is used for this study [7]. All the data used for this study is given in table-1, and table-2.

Table-1: Gas composition of FG-2 and FG-3[7]

Component	Composition (mole%)	
	FG-2	FG-3
N_2	0.001	0.0009
CO_2	0.005	0.005
C_1	0.97	0.98
C_2	0.013	0.012
C_3	0.0008	0.0007
iC_4	0.0002	0.0001
nC_4	0.0003	0.0002
iC_5	0.0003	0.0001
nC_5	0.0002	0.0002
Total	1	1

Table-2: Pressure and Temperature for several gas sand layer in FG-2 and FG 3[7]

Well No.	Sand layer	Pressure (psia)	Temperature (°F)
FG-2	UGS	2940.7	126
	MGS	3722.7	159
	LGS	4032.7	162
FG-3	NGS-II	2862	124
	UGS	2917	125

Methodology of gas properties analysis

1. Calculation of Molecular weight (M_a): The apparent molecular weight of gas composition can be calculated from the each gas component molecular weight and mole fraction. If apparent molecular weight is M_a , mole fraction is y_i and each gas component molecular weight is M_j can be calculated as follows [8].

$$M_a = \sum y_i M_j \quad \text{---------- (1)}$$

Table-3: Calculation of $y_i M_j$ (For well FG-2)

Component	Molecular weight(M_j)	Mole fraction (y_i)	(y_iM_j)
N_2	28.01	0.001	0.0280
CO_2	44.01	0.005	0.2200
C_1	16.04	0.97	15.5588
C_2	30.07	0.013	0.3909
C_3	44.10	0.0008	0.0352
iC_4	58.12	0.0002	0.0116
nC_4	58.12	0.0003	0.0174
iC_5	72.15	0.0003	0.0216
nC_5	72.15	0.0002	0.0144

Table-4: Calculation of $y_i M_j$ (For well FG-3)

Component	Molecular weight(M_j)	Mole fraction (y_i)	(y_iM_j)
N_2	28.01	0.0009	0.0252
CO_2	44.01	0.005	0.2200
C_1	16.04	0.98	15.7192
C_2	30.07	0.012	0.3608
C_3	44.10	0.0007	0.0308
iC_4	58.12	0.0001	0.0058
nC_4	58.12	0.0002	0.0116
iC_5	72.15	0.0001	0.0072
nC_5	72.15	0.0002	0.0144

Here the value of M_j is the each gas component molecular weight [9]

2. Calculation of Gas gravity (γ_g): Gas gravity is defined as the ratio of molecular weight of a natural gas to the molecular weight of air at the same condition [10].
The molecular weight of the air at standard condition is equal to 28.9 [10].It is calculated from the following formula [9].

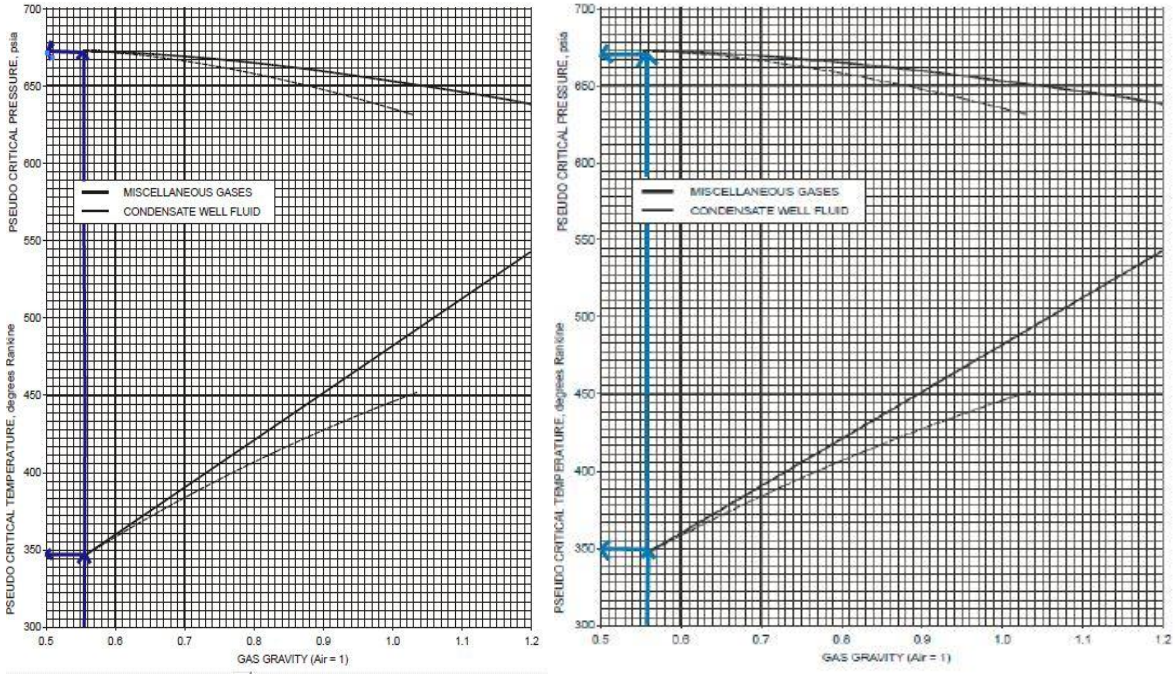
$$\gamma_g = M_{gas} / M_{air} \quad \text{---------- (2)}$$

3. Calculation of Gas Compressibility Factor (Z): It is also known as gas deviation factor. The Standing and Katz correlation, among other methods, is a widely accepted method of determining z-factor manually from charts for natural gas of either known or unknown composition [11].
Step-1: First of all, the Pseudo-critical pressure (P_{pc}) and Pseudo-critical temperature (T_{pc}) is calculated from gas gravity (γ_g) using pseudo-critical properties determination chart in figure-2-4[16].

Step-2: Determination of Pseudo-reduced pressure (P_{pr}) Pseudo-reduced temperature (T_{pr}) using the following formula [9].

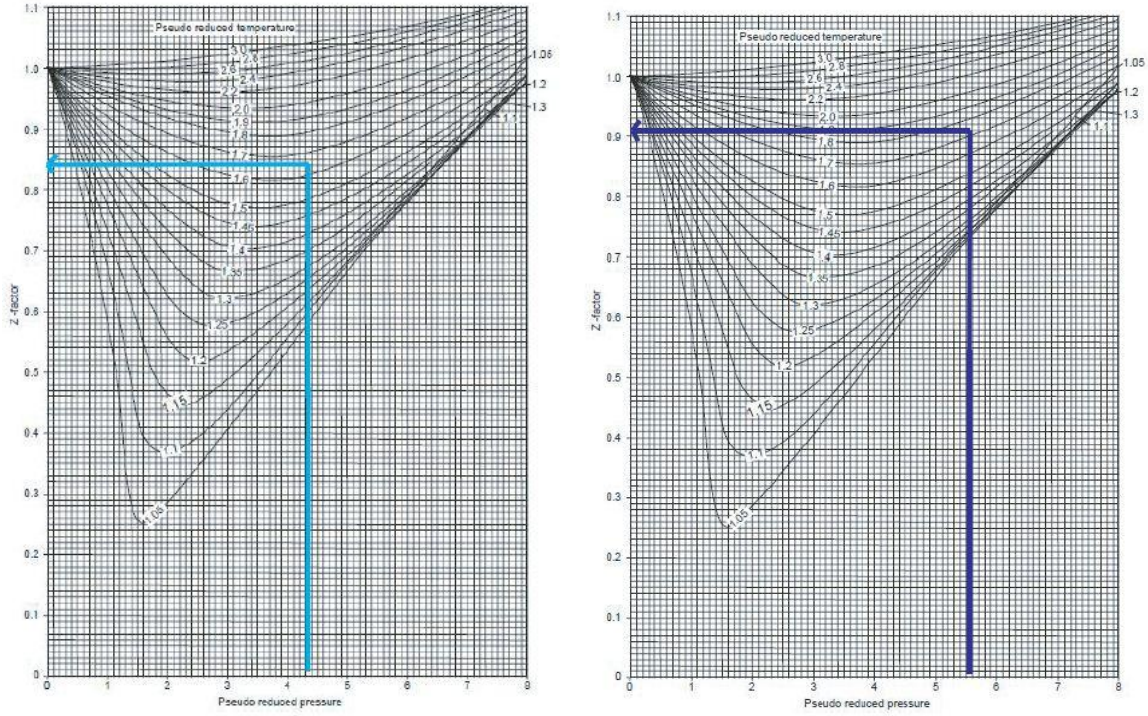
$$P_{Pr} = P/P_{Pc} \quad \text{----------} \quad (3)$$
$$T_{pr} = T/T_{pc} \quad \text{----------} \quad (4)$$

Step-3: Determination of Gas compressibility factor (Z) from the Standing and Katz Chart using P_{pr} and T_{pr} using figure-2 [12].

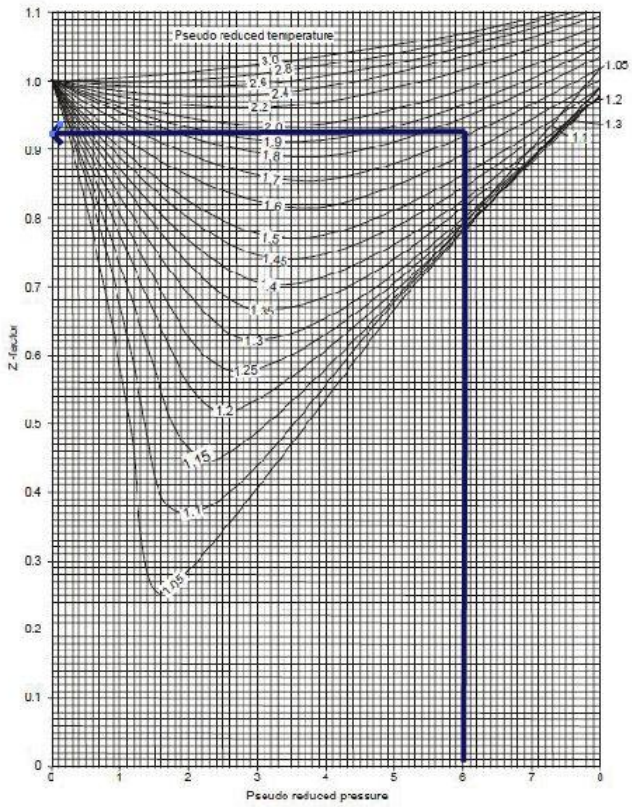


(a) For FG-2 (b) For FG-3

Figure-2(a, b): Pseudo critical properties of miscellaneous natural gases and condensate well fluids [16].

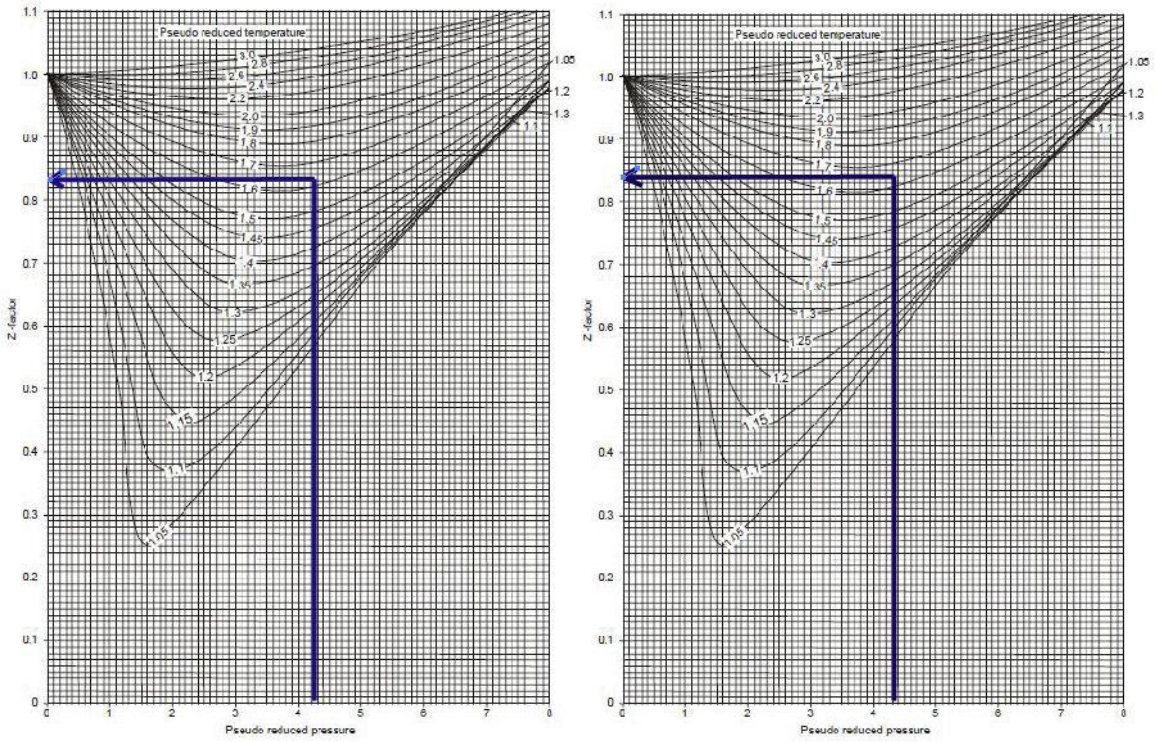


(a) For FG-2 (UGS) (b) For FG-2 (MGS)



(c) For FG-2 (LGS)

Figure-3(a, b, c): The Z-factor correlation chart of Standing and Katz [12].



(a) For FG-3(NGS-ii) (b) For FG-3(UGS)

Figure-4(a, b): The Z-factor correlation chart of Standing and Katz [12].

4. Calculation of Gas Formation Volume Factor (B_g)

The formation volume factor relates the reservoir volume to the volume at standard conditions of any hydrocarbon mixture [10]. It can be calculated from the following formula [13].

$$B_g = 0.02827 \frac{ZT}{P} \quad ft^3/scf \qquad \text{---------- (5)}$$

5. Calculation of Gas Expansion Factor (E)

The gas expansion factor is defined as the ratio of the volume of n moles gas at standard condition to the volume of n moles gas at reservoir conditions [9].

The gas expansion factor can be calculated from the following formulas [9,13].

$$E = 35.37 \frac{P}{ZT} \qquad \text{---------- (6)}$$

$$E = 1/B_g \qquad \text{---------- (7)}$$

6. Density Calculation (ρ_g)

Density of any substances is defined as the mass of the substances per unit volume. The gas density is calculated from the following formula [9].

$$\rho_g = \frac{MP}{ZRT} \quad lb/ft^3 \qquad \text{---------- (8)}$$

Here, R is the universal gas constant.

7. Viscosity Calculation (μ_g)

The viscosity of gas can be determined by the following procedure.

Step-1: Calculate the viscosity of gas for 1 atm ($\mu_{1\ atm}$) using the data γ_g and temperature (T) from the figure-5[10,15].

Step-2: Calculate $\mu_{1\ atm}/\mu$ from the figure-6 [10,15] using the P_{pr} and T_{pr} data and finally calculate viscosity.

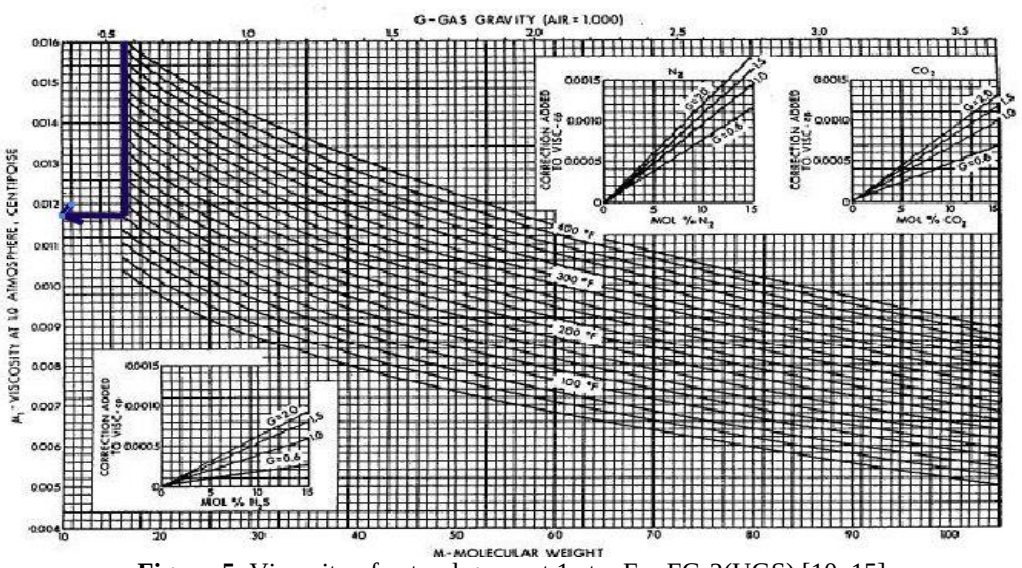


Figure-5: Viscosity of natural gases at 1 atm For FG-2(UGS) [10, 15].

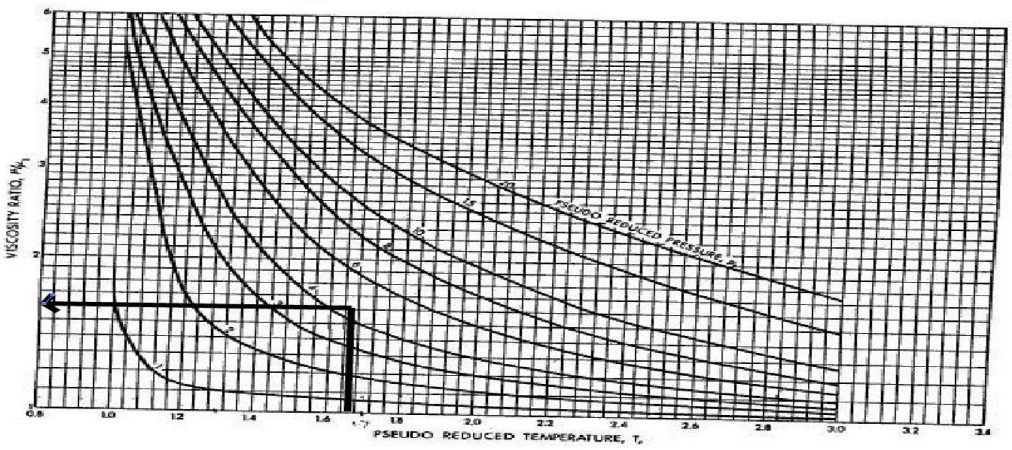


Figure-6: Viscosity ratio at elevated pressure and temperature for FG-2(UGS) [10, 15].

IV. Results And Discussion

All the results of this study like molecular weight, gas gravity, gas compressibility factor or gas deviation factor, gas formation volume factor, gas expansion factor, density of gas and gas viscosity are presented in the Table-5, table- 6, table-7, table-8.

Table-5: Results of Molecular weight and Gas specific gravity (γ_g).

Well Name	Molecular weight	Gas specific gravity
FG - 2	16.2979	0.5625
FG - 3	16.395	0.5659

Table-6: Results of gas compressibility factor (Z) and gas formation volume facto (B_g)

Well Name	Gas Sand Layer	Compressibility factor(Z)	Gas formation volume factor (B_g) $res.\ ft^3/scf$
FG - 2	Upper Gas Sand(UGS)	0.84	4.73×10^{-3}
	Middle Gas Sand(MGS)	0.91	4.27×10^{-3}
	Lower Gas Sand(LGS)	0.92	4.01×10^{-3}
FG - 3	New Gas Sand(NGS-ii)	0.83	4.78×10^{-3}
	Upper Gas Sand(UGS)	0.84	4.76×10^{-3}

Table-7: Results of Gas expansion factor (E) and Density (ρ_g)

Well Name	Gas Sand Layer	Gas Expansion Factor(E)	Density(ρ_g) lb/ft_3
FG - 2	UGS	211.416	9.18
	MGS	234.192	10.147
	LGS	249.376	10.70
FG - 3	NGS-ii	209.205	9.13
	UGS	210.084	9.23

Table-8: Results of Gas Viscosity (μ_g)

Well Name	Gas Sand Layer	Gas Viscosity(μ_g) cp
FG - 2	UGS	0.01872
	MGS	0.0202
	LGS	0.02108
FG - 3	NGS-ii	0.01805
	UGS	0.01832

To calculate the gas compressibility factor, pseudo-critical temperature and pseudo-critical pressure was estimated from the pseudo critical properties curve with the help of gas gravity (Figure-2). The corresponding pseudo-critical temperature for FG-2 is 349 $^{\circ}$R and 350 $^{\circ}$R for FG-3. The pseudo-critical pressure for FG-2 is 670 psia and 669.9 psia for FG-3. With the help of formation pressure and pseudo-critical pressure, the pseudo-reduced pressure is calculated. By the same procedure the pseudo-reduced temperature is also calculated. The pseudo-reduced pressure of FG-2 is 4.389 for UGS, 5.556 for MGS and 6.01 for LGS. The pseudo-reduced temperature for FG-2 is 1.679 for UGS, 1.77 for MGS and 1.78 for LGS. Similarly the pseudo-reduced pressure of FG-3 is 4.27 for NGS-ii and 4.35 for UGS. The pseudo-reduced temperature for FG-3 is 1.668 for NGS-ii and 1.671 for UGS. The gas compressibility factor is then measured with the help of Standing and Katz chart (Figure-3, Figure-4). For measuring the gas density, the universal gas constant, R is used which value is 10.732ft^3 psi/^{0}R lb-mol. The gas density of FG-2 is 9.18 lb/ft^3 for upper gas sand, 10.147 lb/ft^3 for middle gas sand and 10.70 lb/ft^3 for lower gas sand. On the other hand, the density of gas for FG-3 is 9.13 lb/ft^3 (NGS-ii) and 9.23 lb/ft^3 (UGS). So the FG-2 is denser than FG-3 with respect to gas density. Similarly the gas viscosity is higher in FG-2 than that of FG-3. As the FG-2 has higher pressure than FG-3, its viscosity is higher. Viscosity increases with reservoir pressure increase and vice-versa. Viscosity is calculated with the help of $\mu_{1\ atm}$ calculation from figure-5. The FG-2 and FG-3 both contain methane 0.97(mole fraction) or 97% and 0.98 (mole fraction) or 98%, the presence of hydrogen sulfide is zero. So Fenchuganj gas reservoir is sweet gas reservoir. Natural gas is considered "sour" if hydrogen sulfide (H_2S) is present in amounts greater than 5.7 milligrams per normal cubic meters [14].

V. Conclusion

Fenchuganj gas field is one of the productive gas fields in Bangladesh. It locates in the block number 14 and this field is operated by BAPEX. There is no Hydrogen Sulfide present in this reservoir. So it is a sweet gas reservoir which specific gravity is 0.5625 for well FG-2 and 0.5659 for FG-3. The total gas production capacity of Fenchuganj is 35mmscfd according to Petrobangla annual report 2015. The above all estimated gas properties of FG-2 and FG-3 by this study are mathematical based which can be used for further reserve estimation.

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