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Research Papers

Investigation of the Effects of Oil-Gas Ratio in Crude Oil Production

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Abstract: With rising crude oil consumption and limited conventional petroleum reserves, big crude oil resources are projected to play more crucial roles in the petroleum industry's future. Also, optimal tubing size selection might result in maximum production from a crude oil well. More so, when drilling a well in a reservoir of any kind, the selection of optimal tubing size must be considered, especially in solution gas drive reservoirs where there is a possibility of generating an increase in gas as reservoir pressure decreases. This research work is therefore focused on investigation of the effects of oil-gas ratio in crude oil production. To forecast the behavior of producing GOR, Tracy methods for estimating a solution gas drive reservoir's performance was employed. The results showed that the bottom hole pressure decreases as tubing diameter increases. Besides, as GOR rises from 840 scf/stb to 1052 scf/stb, the tubing curves shift to the right, indicating an increase in crude oil production. Furthermore, at the lower IPR curves (IPR4 and IPR5), the well cannot be constructed using the larger tubing (4-in).

Keywords: Gas Oil Ratio, Gas Liquid Ratio, Tubing, Crude Oil Production, Pressure.

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INTRODUCTION

The solution gasoil ratio (GOR) just describes the quantity of gas dissolved in reservoir fluids at reservoir pressures [1]. Figure 1 [2] is a typical solution GOR versus pressure curve. The GOR is also defined as the oil produced after the dissolved gas has developed from it at the surface divided by the volume of gas that originates from the generated oil (or water) at atmospheric pressure. measured in standard cubic feet (SCF) [3-6]. Correspondingly, in heavy oil, the solution gasoil ratio (Rs) is larger than in light oil. When there is no dissolved gas in the oil, it has a ratio value of 0 SCF/STB, whereas very light oil has a value of 2100 SCF/STB [7-9]. While waiting for the bubble point pressure to be reached, the solution gasoil ratio tends to grow linearly [10]. "The maximum pressure at which the first gas appears" [11–14] is used to define the bubble point pressure (BPP). Since no gas is released from the oil since it is still contained in the reservoir, as shown in Figure 1, the Rs have a constant value above the bubble point.

Furthermore, wellbore optimization is primarily evaluated during the stages of well completion. Tubing joints range in length from 18 to 35 feet, with the average being around 30 feet. There are numerous outside diameter diameters available for tubing. 2 3/8-in, 2 7/8-in, 3 1/2-in, and 4 1/2-in are the most frequent sizes. The API defines tubing as pipe with an outside diameter ranging from 1 in to 4 1/2 in. Casing refers to larger diameter tubulars (4 1/2-in to 20-in) [15-17]. Also, production optimization identifies ways to enhance output while decreasing operating expenses. The main purpose is to maximize the well's profitability. To attain and sustain this, it is critical to examine and monitor several sections of the production system, such as the wellbore sand face, reservoir, generated fluids, and surface and downhole production equipment. For production optimization, several strategies are utilized [18]. The system analysis approach, also known as nodal analysis, is the most frequent and widely utilized method. The crucial parameter is the flow rate per well. It determines the number of wells that must be drilled in order to maximize the field's economic output [19]. The nominal tubing diameter is the first characteristic to consider when selecting a tubing string. The steel grades and nominal weight are selected depending on the stress that the tubing will be subjected to during production.

Thirdly, the type of connection and metallurgy are chosen based on how damaging the current and upcoming effluents are. In fact, the many stages stated above overlap, making tubing selection challenging at times. The nominal diameter through weight affects the pipe's inner through diameter while estimating the nominal pipe diameter [20]. The maximum flow rate that corresponds to the erosion velocity and the minimum flow rate necessary to lift water or condensate are the two factors that set the flow rates that can pass through it. Tubing having a diameter of less than 2 7/8 in is known as macaroni string and is typically used for well operations employing concentric pipe. Also keep in mind that the space needed by the tubing couplings limits the largest nominal tubing diameter that may be run inside the production casing [21].

MATERIALS AND METHODS

The capacity to predict reservoir performance in the future is required for scheduling artificial lift operations, sizing the appropriate equipment, and planning reservoir expansion from an economics perspective. Additionally, forecasting a depletion-drive reservoir's primary recovery performance in terms of Np and Gp, the reservoir PVT data must be available. Initial fluid saturation, initial oil in place, initial hydrocarbon PVT, and relative permeability are some of these data. Every other method for predicting a reservoir's performance in the future is essentially reliant on the appropriate material balance equation (MBE) and an appropriate saturation equation for the immediate GOR. However, the projection is just limited to the current GOR. The computations are also performed again at a number of hypothetical reservoir pressure decreases. Although there are a number of ways that can be utilized to forecast how the solution gas drive reservoir would operate, Tracy's method was employed in this study.

For a depletion drive reservoir without water ingress, Tracy (1955) [22] proposes that two functions of PVT variables can be used to modify and express the general material balance equation. The formula that follows assumes that there is an initial oil instead of one STB.

$$N = N_p\emptyset_o + G_p\emptyset_g \qquad 1)$$

where,

$$\emptyset_o = \frac{B_o - R_s B_g}{(B_o - B_{oi}) + (R_{si} - R_s)B_g} \qquad (2)$$

$$\emptyset_g = \frac{B_g}{(B_o - B_{oi}) + (R_{si} - R_s)B_g} \qquad (3)$$

The following steps where followed to enable the prediction;

i. An average reservoir pressure was selected
ii. The values of the PVT functions were calculated
iii. The GOR using data from PVT and expected reservoir pressure was estimated
iv. The average instantaneous GOR was calculated using equation (4)
v. The incremental oil production was calculated from equation (5)
vi. The cumulative crude oil production was determined using equation (6)
vii. Calculations were made for the crude oil and gas saturation at a certain average reservoir pressure.
viii. The relative permeability ratio Krg/kroat Sg was obtained
ix. The instantaneous GOR was obtained
x. The estimated GOR obtained was compared with the calculated GOR. The next step was only moved to if the numbers fall within an acceptable tolerance range, go ahead; if not, set the estimated GOR to the calculated GOR, and repeat steps 2 and 3.
xi. The cumulative gas production determined using equation (7)

$$GOR_{avg} = \frac{GOR_{assumed} + R_{so}}{2} \qquad (4)$$

$$\Delta Np = \frac{1-(N_P^*\emptyset_O + N_P^*\emptyset_g)}{\emptyset_O + (GOR)avg\emptyset_g} \qquad (5)$$

$$N = N_p^* + \Delta N_p \qquad (6)$$

$$G_p = G_p^* + \Delta N_p\,(GOR)avg \qquad (7)$$

The prediction's correctness should be verified once again on the MBE, and the step 1 calculation should be redone because the results depend on 1 STB of oil being initially present.

$$N = N_p\emptyset_o + G_p\emptyset_g = 1 \mp Tolerance \qquad (8)$$

where;
Boi = Initial Oil Formation Volume Factor, rb/stb
Bo = Oil Formation Volume Factor, rb/stb Gas
Bg = Formation Volume Factor, bbl/scf
d = pipe diameter, L, in = friction factor, dimensionless
g = gravitational acceleration, L/t2, ft/sec2
gc= conversion facto, dimensionless, 32.2 ft-Ibm/Ibf-sec2
GLR = Gas Liquid Ratio, (SCF/STB)
GOR = Gas oil ratio, (SCF/STB)
LGOR = Low GOR
N = Initial Oil in Place, STB
Np = Cumulative Oil Production, stb/day
OD = outer diameter, inches is the bubble point pressure, psi
Rn = Gas Oil Ratio at a specific reservoir pressure, scf/stb
Rsi = Initial Solution Gas oil ratio, scf/stb
Sg = Gas Saturation Oil Saturation

RESULTS AND DISCUSSION

For a specific range of GOR, Tables 1 displays the fluctuation in both pressure and the rate of oil production. The prediction approaches produced almost the identical GLR at a specific GOR and water cut according to Table 1. The findings only shown that Tracy methods can be utilized to accurately estimate the immediate gas/oil ratio for an oil well. Additionally, utilizing Table 1's water cut and the same GLR at a specific GOR. and there was a very minimal error margin between the computed and estimated GOR.

Table 1: shows the Tracy prediction methods' estimated GLR for various water cuts.

W_c (%)	GOR (sfc/stb)	Tracy Method	Calculated	Difference
		GLR (scf/stb)		
25	1800	1300	1300	0
20	1800	1500	1400	100
15	1800	1700	1500	200
25	4500	2750	2700	50
20	4500	3300	3100	200
15	4500	4100	3650	450

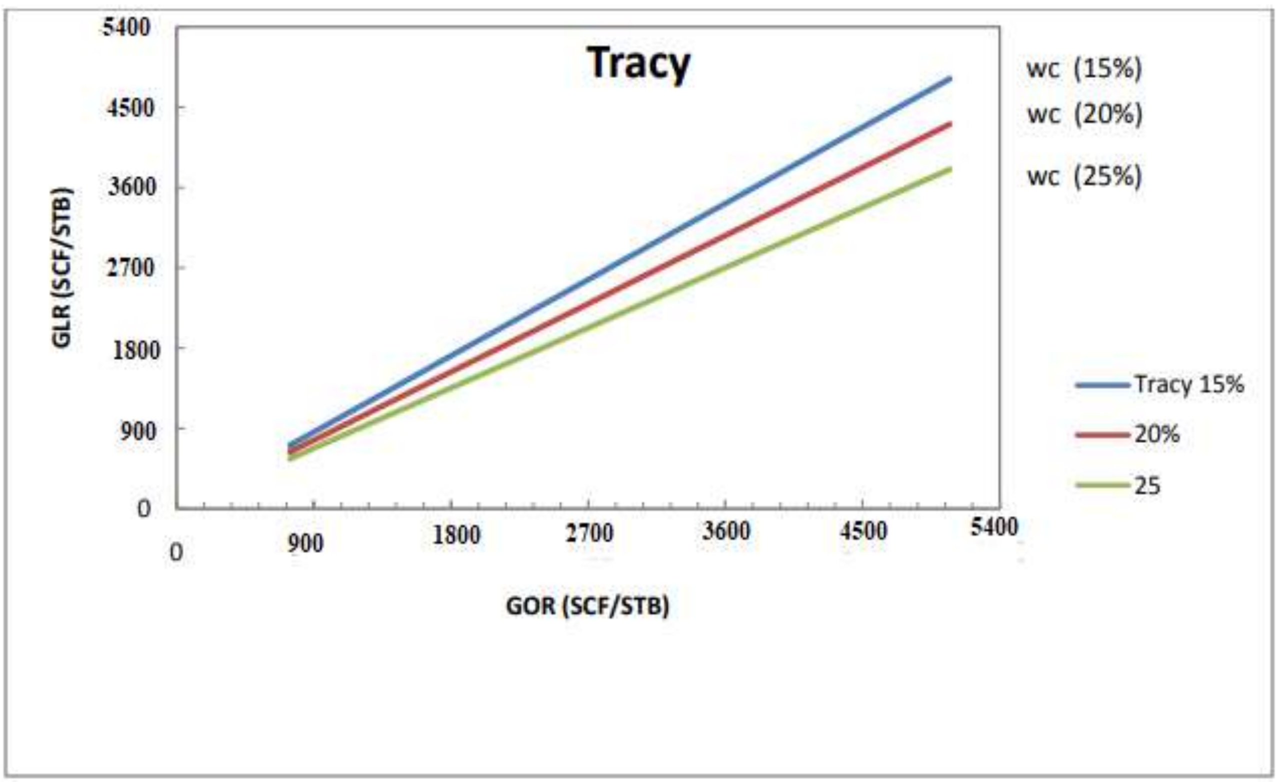

Figure 2: GLR against GOR at varying water cut ratios (Tracy's method)

The GOR was estimated using Tracy's steps, which are outlined above for the prediction of produced GOR. The plot of the instantaneous GOR against pressure shown in Figure 3 was created using the generated data. For a solution gas drive reservoir, the initial crude oil in place is 3.7 MMSTB, the connate water saturation is 35%, the oil saturation is 0.65, the bubble point pressure is 2500 psi, and the abandonment pressure is 700 psi.

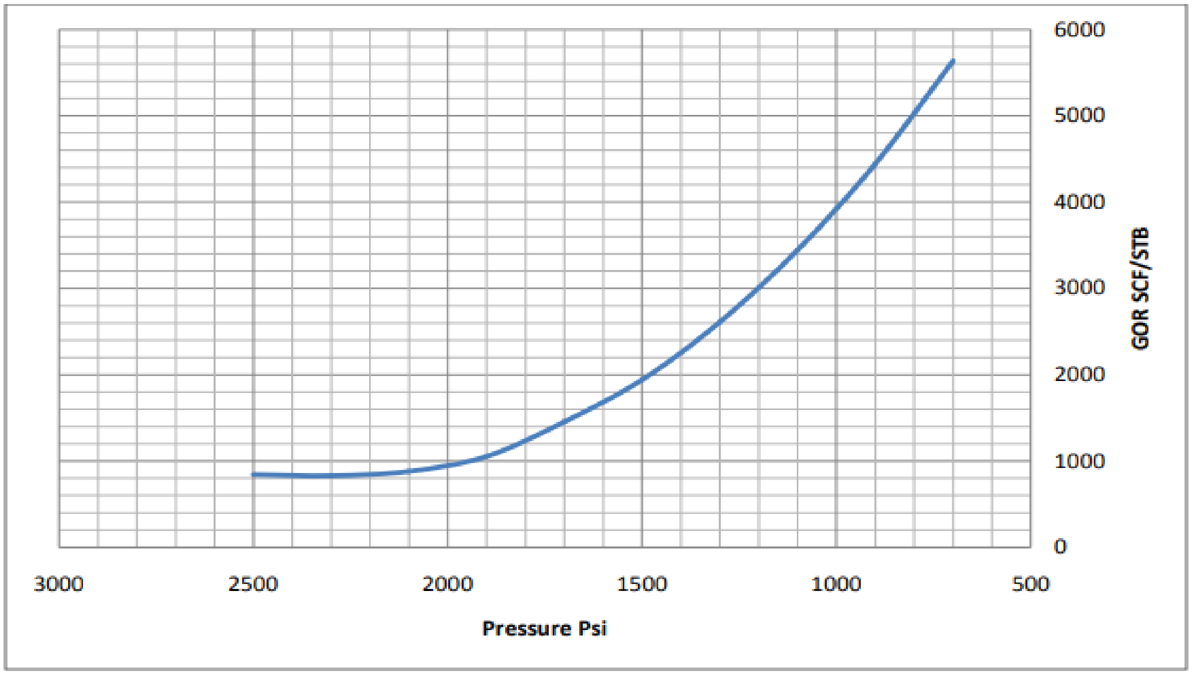

Figure 3: Variation of GOR with reservoir pressure

The tubing performance curves as shown in Figure 4 for different sizes tubing IPR1 and IPR4 curves intersect, making tubing selection possible. More so, IPR1 to IPR3 curves and the 4-in tubing performance curve cross each other. Additionally, the TPR curves for the 3.1/2-in, 2.75-in, and 2 3/8-in tube sizes converge as it approaches IPR5. Therefore, at lower IPR curves (IPR4 and IPR5), the larger tubing size (4-in) cannot be used to build the well. The 4-in tubing size may produce up to 2100 stb/day at a bottom hole pressure of 1375 psi, according to the IPR1 curve, but the 2 3/8-in can only produce 1310 stb/day at a significantly higher bottom hole pressure of 2090 psi. It was observed that as tubing diameter is increased, the bottom hole pressure generally tends to drop. In addition, the increase in oil output is accompanied by a change in the tubing curves to the right when GOR increases from 840 scf/stb to 1052 scf/stb.

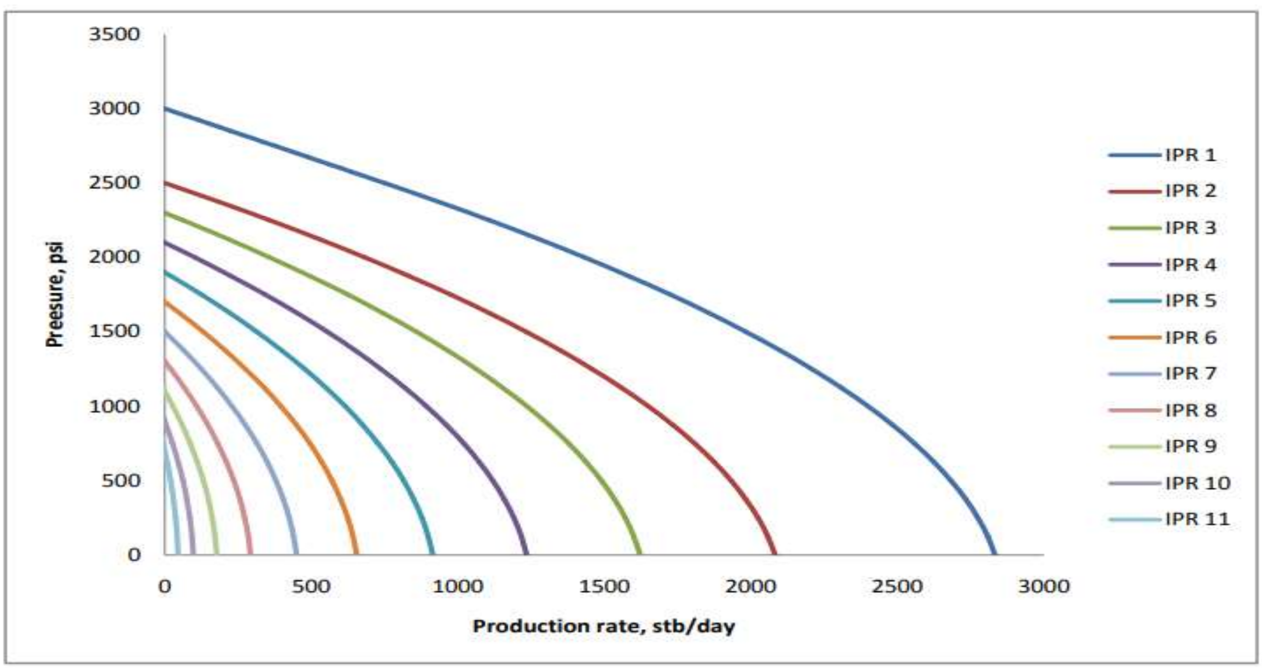

Figure 4: Future inflow performance relationships curves

CONCLUSION

The outcomes for the trends in crude oil production show that GOR production increases the amount of production to some extent. It was observed that the GOR generated decreasing reservoir pressure cannot be regulated, and as a result, it is essential to conduct an analysis of all tubing sizes offered in order to identify the precise tubing sizes that will result in a notable increase in output. However, the outcomes of this study's research will undoubtedly provide guidance in selecting the best tubing size for the well's completion and gas lift design. In addition, the critical point depends on the tubing size utilized and the state of the well at the time.

REFERENCES

[1] Valkó, P.P., McCain, W.D. (2003). Reservoir Oil Bubble Point Pressures Revisited; Solution Gas−Oil Ratios and Surface Gas Specific Gravities. J. Pet. Sci. Eng., 37: 153−169

[2] Bahadori, A. (2016). Fluid Phase Behavior for Conventional and Unconventional Oil and Gas Reservoirs; Gulf Professional Publishing.

[3] Elmabrouk, S., Shirif, E. (2011). Prediction of Bubblepoint Solution Gas/Oil Ratio in the Absence of a PVT Analysis. Braz. J. Pet. Gas, 5, 227

[4] Ahmadi, M. A., Zendehboudi, S., James, L. A., Elkamel, A., Dusseault, M., Chatzis, I., Lohi, A. (2014). New Tools to Determine Bubble Point Pressure of Crude Oils: Experimental and Modeling Study. J. Pet. Sci. Eng., 123: 207−216

[5] Bahadori, A. (2016). Fluid Phase Behavior for Conventional and Unconventional Oil and Gas Reservoirs; Gulf Professional Publishing.

[6] Pooladi-Darvish, M., and Firoozabadi, A. (1999). Solution-Gas Drive in Heavy Oil Reservoirs. JCPT, 38(4): 54-60.

[7] Hassan, O. F. (2011). Correlation for Solution Gas-Oil Ratio of Iraqi Oils at Pressures below the Bubble Point Pressure. Iraqi J. Chem. Pet. Eng., 12, 1−8.

[8] Shen, C., and Batycky, J.P. (1999). Observation of Mobility Enhancement of Heavy Oils Flowing Through Sand Pack under Solution Gas Drive. JCPT, 38(4): 46-53

[9] Desouky, M., Tariq, Z., Alhoori, H., Mahmoud, M., Abdulraheem, A. (2021). Development of Machine Learning Based Propped Fracture Conductivity Correlations in Shale Formations. In SPE Middle East Oil & Gas Show and Conference; OnePetro.

[10] Tariq, Z., Aljawad, M. S., Murtaza, M., Mahmoud, M., Al-Shehri, D., Abdulraheem, A. A (2021). Data-Driven Approach to Predict the Breakdown Pressure of the Tight and Unconventional Formation. In SPE Annual Technical Conference and Exhibition; OnePetro.

[11] Tariq, Z., Hassan, A., Waheed, U. B., Mahmoud, M., Al-Shehri, D., Abdulraheem, A., Mokheimer, E. M. A. (2021). A Data-Driven Machine Learning Approach to Predict the Natural Gas Density of Pure and Mixed Hydrocarbons. J. Energy Resour. Techno., 143, 92801

[12] Zadeh, L. A. (1996). Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems: Selected Papers by Lotfi a Zadeh (Advances in Fuzzy Systems-Applications and Theory); World Scientific: 394−432.

[13] Sheng, J. J., Hayes, R.E., Maini, B.B., and Tortike, W.S. (1995). A Proposed Dynamic Model for Foamy Oil Properties," SPE 302553, presented at the International Heavy Oil Symposium, Calgary, Alberta, Canada, 19-21.

[14] Smith, G. E. (1998). Fluid Flow and Sand Production in Heavy-Oil Reservoirs Under Solution-Gas Drive SPE Production Engineering, 3(2): 169-180

[15] Vasquez, M., Beggs, H. D. (1980). Correlations for Fluid Physical Property Prediction. J. Pet. Technol., 32, 968−970

[16] Glaso, O. (1980). Generalized Pressure-Volume-Temperature Correlations. J. Pet. Technol., 32, 785−795

[17] Al-Marhoun, M. A. (1988). PVT Correlations for Middle East Crude Oils. J. Pet. Technol., 40, 650−666

[18] Lasater, J.A. (1958). Bubble Point Pressure Correlation. J. Pet. Technol., 10, 65−67. (13)

[19] Petrosky, G.E., Farshad, F.F. (1993). Pressure-Volume-Temperature Correlations for Gulf of Mexico Crude Oils. In SPE annual technical conference and exhibition; Society of Petroleum Engineers

[20] Bebaha, M. (2014). Estimation of GOR at Reservoir Pressures Below Bubble Point Pressure Using GMDH (Group Method of Data Handling); Universiti Teknologi PETRONAS

[21] Mathew, E.S. Tembely, M., AlAmeri, W., Al-Shalabi, E. W., Shaik, A.R. (2021). Artificial Intelligence Coreflooding Simulator for Special Core Data Analysis. SPE Reserv. Eval. Eng., 24, 780−808

[22] Chung, T.H., Carroll, H. B., Lindsey, R. (1995). Application of Fuzzy Expert Systems for EOR Project Risk Analysis. In SPE Annual Technical Conference and Exhibition; One Petro.