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Effect of Gas-Oil Ratio on production rate in Z Field Well X

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ABSTRACT

Gas-oil ratio (GOR) is the ratio of the volume of gas that is liberated from the solution to the volume of oil and this situation occurs because of the pressure and temperature decrease to the surface condition (60 ^{0}F and 14.7 psi). When the reservoir pressure above the bubble point pressure there is no prevailing free gas, however in gas cap reservoir and in solution gas drive reservoir which the reservoir is depleted, reservoir pressure is going to decline and gas will come out of the solution, when gas is mobile, producing GOR occurs. This study is conducted in Z field well X which is flowing naturally to the surface with the purpose to understand how low increase of GOR has an impact on production rate and the optimum tubing size selection in well X. Thus, Vogel's equation method is used to compute the inflow of fluids into the wellbore by performing steady-state, multiphase flow simulator (PIPESIM v2011.1). Case 1 with producing GOR 60 scf/stb, case 2 with GOR 90 scf/stb and case 3 with producing GOR 120 scf/stb and tubing ID varies from: 1.751-in, 2.441-in and 3.068-in. The results indicate that when amount of gas-oil ratio increases production rate is also going to increase in Z field well X and the larger the tubing ID the greater the production rate, in this case 3.068-in is the optimum tubing ID based on higher production rate.

Keywords: Gas-oil ratio, nodal analysis, tubing, production rate.

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1. Introduction

Production in oil and gas industry is defined as an activity which include extraction of saleable hydrocarbons in the solid, liquid or gaseous state (Peacock et al., 2015). Production activity is to deliver oil and gas from underground to the surface and into the downstream facilities through production systems. Generally, there are two methods in production of oil and gas such as: natural flow and artificial lift methods.

In the beginning of production phase, oil and gas will flow naturally from reservoir up to the surface and these naturally flowing wells have enough reservoir pressure or down-hole pressure to reach suitable wellhead production pressure and maintain an acceptable well flow in an economical rate (Devold, 2009). However during the production, reservoir pressure is going to decline causing production rate not to flow in an economical rate, therefore in order to do the optimization there will be a transition from natural flow to the artificial lift method and Guo et al., (2007) explains that to obtain high production rate of a well is to increase production pressure drawdown by reducing the bottom hole pressure with artificial lift methods.

In production phase, there are several problems that will be encountered during production. Guo et al., (2007) states that to enhance production it is crucial for engineers to identify problems that cause low production rate of wells, quick decline of the desirable production fluid, or rapid increase in the undesirable fluids, therefore for oil wells these problems include: low productivity, excessive gas production, excessive water production, sand problem and for gas wells these problems are: low productivity, excessive water production, liquid loading, and sand production. Gas-Oil ratio is the volume of gas which comes out of the solution to the volume of oil as reservoir pressure decline below the bubble point pressure and solution gas-oil ratio is the volume of gas dissolved at standard conditions in a unit volume of stock tank oil at certain pressure and temperature (Kumar, 2008). GOR has an impact on production rate mainly in oil production, Pressure decline rate increase, production rate is also increased in solution gas drive reservoir because pressure decline rate generates larger super saturation and faster nucleation that leads to more-dispersed gas bubbles. And under field conditions pressure decline rate change with space and time (Sheikha and Pooladi-darvish, 2009). Many studies has been done regarding the effect of GOR and in this case, the effect of producing GOR and optimum tubing selection in Z field well X that is flow naturally is going to be taking into account.

2. Literature Review

GOR is defined as a volume of gas (at standard condition, 60 ^{0}F and 14.7 psi) liberated from the oil (Ratnakar et al., 2019). Basically in production, gas-oil ratio means the ratio of gas that comes out of the solution to the volume of oil and this situation occurs because of the pressure and temperature decrease to the surface condition. Solution gas oil ratio (also called gas in solution), Rs, is defined as gas dissolved in oil at any pressure and temperature when it is taken down into reservoir condition (El-Banbi, 2018). Solution gas oil ratio will remain constant in undersaturated reservoir or when reservoir pressure is greater than bubble point pressure however when reservoir pressure fall below the bubble point

Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

pressure, gas bubbles and coalesce to form gas phase as gas is mobile (Kraus et al., 1993). Instantaneous gas-oil ratio is defined as the produced gas-oil ratio (GOR) at any particular time is the ratio of standard cubic feet of total gas being produced at any time to the stock tank barrels of oil being produced at that same instant (Ahmed, 2012).

Tubing is relatively small-diameter pipe that is run into a well to serve as a conduit for the passage of oil and gas to the surface (Oil & Gas Glossary). API acknowledges two tubing ranges: Range 1 from 20 to 24 ft and Range 2 from 28 to 32 ft, range 2 is normally used and shorter tubing joints (pup joints) are available in 2-, 3-, 4-, 6-, 8-, 10- and 12-ft lengths with a tolerance of $\pm$ 3 in (petrowiki, 2015). According to API 5CT (2011), the range of tubing outside diameter (OD) from 1.050 inch to 4-1/2 inch and tubing inside diameter (ID) varies from 0.7421 inch to 3.9582 inch.

Gilbert (1954) in his study, he introduced Inflow Performance Relationship (IPR) which is a basic necessity in equipping and operating oil wells through measurement of static pressure in the well and mass rate inflow of each liquid. The Inflow Performance Relationship (IPR) curve is the plot of flowing bottom-hole pressures versus the oil/gas production rates at that pressure values (Mohamed and Abdalla, 2020). Thus, IPR means fluids that a reservoir can deliver to the bottom hole or flow rate of the reservoir to the bottom of the well (wellbore). While Tubing Performance Curve (TPC) or Vertical Lift Performance (VLP) also known as outflow means fluids that a well can deliver from bottom-hole to the surface with a specified wellhead pressure or what bottom-hole pressure should be for each flow rate inside the tubing.

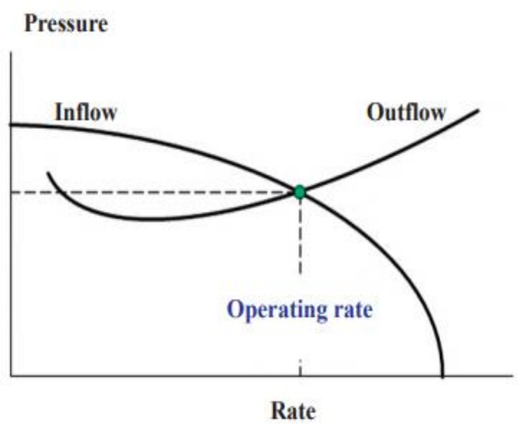

Figure 1. System of nodal analysis (Lea, 2019)

The intersection between inflow and outflow is called operating point which is the actual rate of the well that is performed using nodal analysis. Nodal analysis for well performance is based on the principle that a reservoir inflow and wellbore outflow can be independently characterized as functions of flow rate and pressure (Duncan *et al.*, 2015). The objective of system analysis is to combine the various components of the production system for an individual well to estimate production rate and optimize the components of the production system (Beggs, 2003).

There are several empirical methods that is used to generate current future IPR: Vogel; Fetkovich; Jones et al.; Richardson and Shaw; Wiggins; Klins and Majcher; Sukarno and Wisnogroho (Daoud et al., 2017).

In a two phase flow reservoir, solution gas drive reservoir, straight line method is known to have limitations in such a reservoir thus, Vogel (1968) introduced an equation of a curve that give a reasonable empirical:

$$\frac{Q_o}{(Q_o)_{max}} = 1 - 0.2\left(\frac{P_{wf}}{P_r}\right) - 0.8\left(\frac{P_{wf}}{P_r}\right)^2$$

Where:

Qo = Oil rate
Q_{max} = Maximum oil flow rate, i.e., AOF
Pr = current average reservoir pressure, psig
Pwf = pressure flowing well, psig

According to Chang et al., (1986), three main reasons for producing high GOR in a well are caused by gas underrunning shale complexes, evolution of solution gas and gas coning. Beliveau (2004) in his work explains that there are three major factors that have an impact on gas-oil ratio (GOR) performance such as gas-oil relative permeability curve, the presence of initial gas cap and the strength of any associated aquifer. Generally, once producing GOR occurs it has an impact directly on production rate which can be one of the reservoir driving mechanisms to push fluids up to the surface as Slider (1983) in his work explains that when gas begins to flow from reservoir to the well along with oil, the production rate will increase during the initial phase as a result of an increase of fluid viscosities in the reservoir. However, Chukwueke *et al*., (1998) and Ivanov *et al.*, (2016) argue that GOR can suspend the production of the well, in reservoirs with a thin oil rim below a gas cap, oil production can be severely hampered by gas coning problems especially in horizontal wells as gas coning and early gas breakthrough in producer can lead to significant reduced of oil recovery and the resulting early suspension of wells due to high GOR. When producing GOR is too higher which equal or greater than solution GOR can cause problem such as pressure loss or liquid loading along the well which caused by the bubbling of gas.

Tubing size selection plays an essential role in production phase in order to flow fluids from the bottom of the well up to the surface. Shadizadeh and Zoveidavianpoor (2009) states that large tubing is good for the higher flow rate, low pressure loss and lower fluid velocity desirable during the early life of a well however, as reservoir pressure and flow rate decline, large tubing may become less advantageous as liquid hold up problem encountered, thus smaller tubing size maybe necessary. And Nwanwe *et al.* (2020) argues that there are three criteria for optimum tubing size (OTS) selection such as: (1) the difference between the operating flow rate of the considered OTS and the immediate larger tubing must be minimal; (2) the considered OTS must be cheaper than the larger tubing sizes; (3) the considered OTS must be able to produce when the reservoir pressure drop to 75% of its original value.

Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

3. Research Methodology

3.1. Data Collection

These data are quantitative data from Z field well X which is located in onshore. Reservoir rock is sandstone with the porosity of 20% and average reservoir pressure 4000 psi; bubble point pressure 4250 psi; bottom-hole pressure 3500 psi; perforation depth 7800 ft and production rate is 1800 bbl/d; reservoir temperature 210 ^{0}F; tubing depth at 7700 ft and ambient temperature is 80 ^{0}F.

3.2. Diagram Research

a). Methodological Approach

This study is carried out to understand how low increase of GOR has an impact on production rate and to select optimum tubing size in well X and in this case, higher production rate is the parameter for optimum tubing size selection. The required data for this study is the PVT data and wellbore data from the well. Data used for this study is collected from secondary data.

b). Data Pre-processing

Data collection is the process of gathering the data for a particular purposes or to provide solution to the relevant questions. The tool used to collect the existing data from research journal. The dataset were taken from journal that has been published by the authors Sadeed and Al Nuaim in 2017. Then these data is used to develop new approach which is to analyze the impact of gas-oil ratio on production rate and optimum tubing size based upon tubing specification in well X.

c). Data Analysis

Prior to the data analysis, the dataset was checked for the missing data. Thus, variation of GOR includes: 60 scf/stb, 90 scf/stb and 120 scf/stb and tubing ID differs from 1.751-in, 2.441-in and 3.068-in to examine the effect of GOR on production rate. The data then analyzed using PIPESIM software and two phase IPR method or Vogel equation is used to do the calculation.
The Vogel equation is preferred is this computation due to the condition of the reservoir which is two phase flow (oil and gas).

4. Result and Discussion

4.1. Nodal Analysis of Gas-Oil Ratio (GOR) Variation with an Outflow 2.441 in

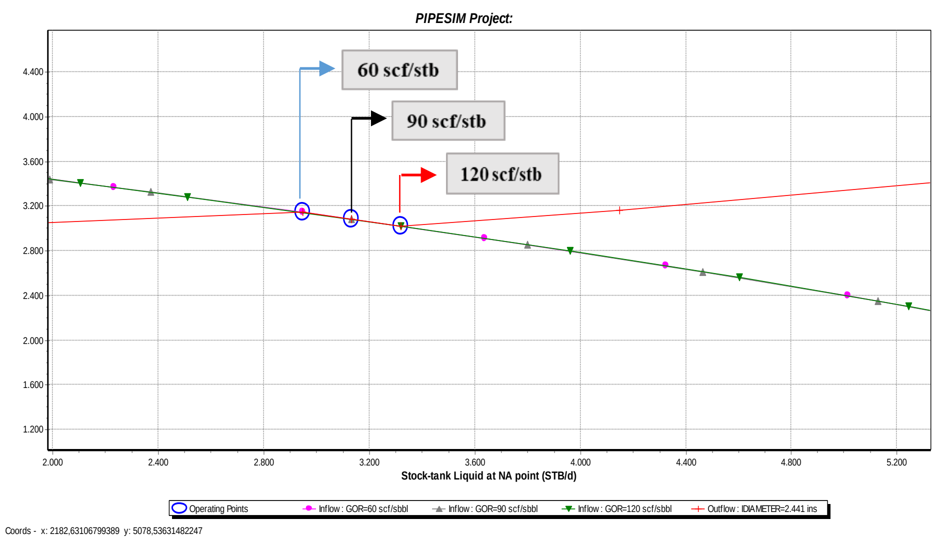

Figure 2. Result of Nodal Analysis of GOR variation with 2.441-in

Figure 2. above reveals the result of nodal analysis of inflow Gas-Oil ratio variation 60 scf/d, 90 scf/d and 120 scf/d with a tubing inside diameter 2.441 in. During production, nodal analysis plays an important role as an approach that is used in oil and gas well to optimize the production rate through the diagram of pressure-rate in a well. Result of the nodal analysis shows that the production rate increases with an increase in the instantaneous GOR, in this case, tubing ID 2.441-in with instantaneous GOR 60 scf/stb the production rate is 2,796.99 bbl/d; when instantaneous GOR increases to 90 scf/stb the production rate is 2,957.49 bbl/d; instantaneous GOR further increase to 120 scf/stb the production rate increases to 3,149.54 bbl/d. The low increase of GOR has the ability to push more oil because of an increase in the fluid viscosities which affect the velocity of the fluids itself to flow faster up to the surface and Slider (1983) said that once gas begins to flow the GOR increases rapidly and during the initial phase of producing GOR, gas has the ability to lighten the fluid density thereby it may increase the production rate.

4.2. Nodal Analysis of Tubing ID Variation With Each Case of GOR (60, 90 and 120 scf/stb)

Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

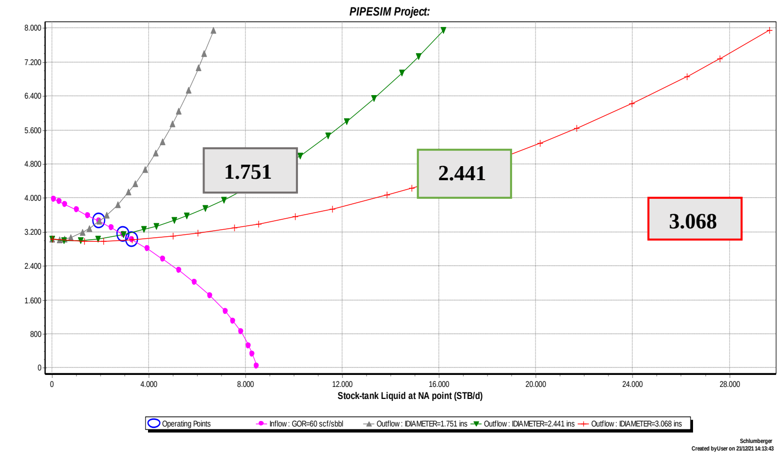

Figure 3. Result of Nodal Analysis with Tubing ID Variation and GOR 90 scf/st

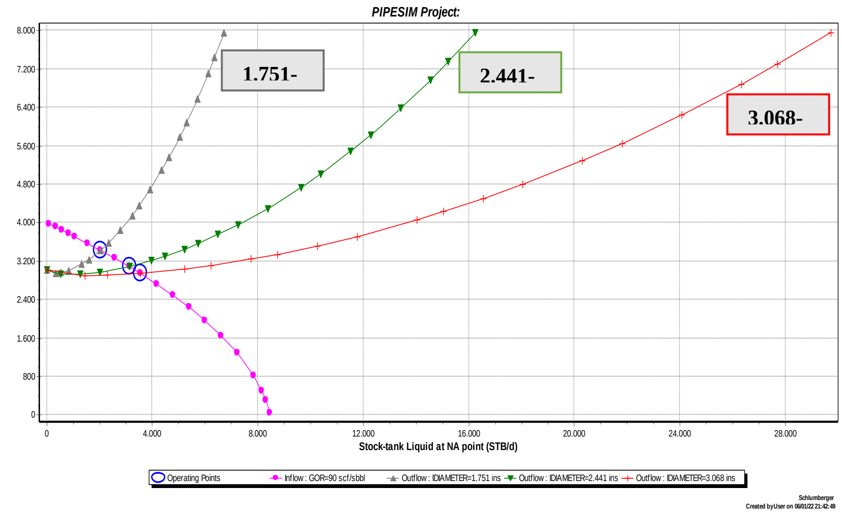

Figure 4. Result of Nodal Analysis With Tubing ID Variation and GOR 90 scf/stb

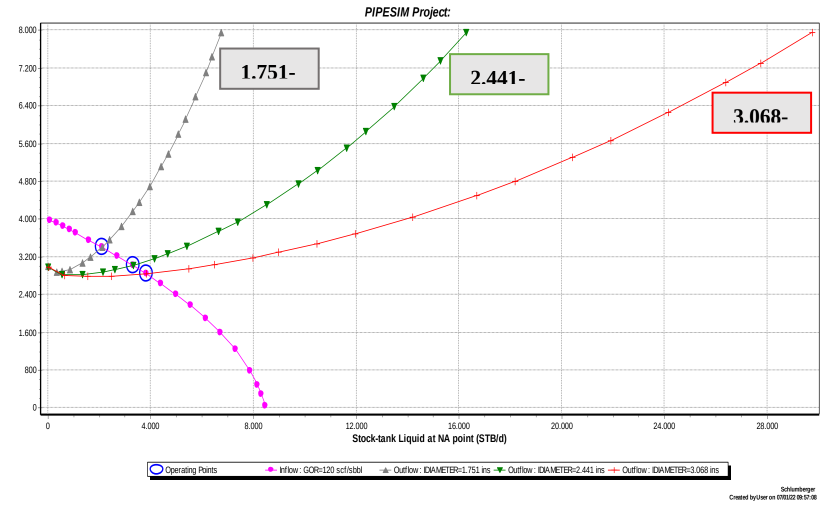

Figure 5. Result of Nodal Analysis With Tubing ID Variation and GOR 120 scf/stb

Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

Figure 3, 4, and 5 illustrate the results of nodal analysis which is performed separately with tubing inside diameter variation and each case of GOR in order to select the optimum tubing size. Nodal analysis of GOR 60 scf/stb with tubing ID 1.751-in the production rate is 1,874.80 bbl/d; tubing ID 2.441-in the production rate increases to 2,805.77 bbl/d; and when having tubing ID 3.068-in production rate further increases t 3,141.44 bbl/d. Production rate of nodal analysis with GOR 90 scf/stb and tubing inside diameter 1.75-in, 2.441-in and 3.068-in are: 1,951.91 bbl/d; 2,957.51 bbl/d; and 3,345.47 bbl/d. And the production rate of nodal analysis with GOR 120 scf/stb and tubing inside diameter 1.75-in, 2.441-in and 3.068-in are: 2,029.32 bbl/d; 3,147.66 bbl/d; and 3,589.33 bbl/d. Apart from the low increase of GOR, results of NA of tubing ID variation shows that when tubing ID is larger the amount of production rate is increasing and one of the major factors cause this increase is higher pressure in the reservoir. As higher reservoir pressure will cause higher velocity therefore when tubing inside diameter is larger, fluids will go up with higher quantities by occupying the space of the large tube than smaller tubing sizes and Nwanwe *et al.*, (2020) states that the operating flow rate will increase with increase in tubing size as a result of decrease in frictional pressure loss. And in order to boost the production rate it is good to have larger tubing size which lead to high quantities of production in a certain time. However, there are several controversies among authors regarding the tubing size selection as Belyadi et al. (2019) argues that having the larger than necessary tubing size can cause a faster need for using artificial lift as a result of pressure decline in a well which cause production rate to become uneconomical. Furthermore, having larger tubing size in a well will cause oil production to reach its peak earlier and shorter lifetime production.

Table 1. Comparison of Each Case of GOR on Production Rate with Each Tubing id Using Nodal Analysis

Tubing ID	Production Rate		
	GOR 60 scf/stb	**GOR 90 scf/stb**	**GOR 120 scf/stb**
1.751-in	1,874.80 bbl/d	1,951.91 bbl/d	2,029.32 bbl/d
2.441-in	2,805.77 bbl/d	2,957.51 bbl/d	3,147.66 bbl/d
3.068-in	3,141.44 bbl/d	3,345.47 bbl/d	3,589.33 bbl/d

Table 1 above illustrates the comparison of production rate with each case of gas-oil ratio and tubing inside diameter in which comparison of production rate of GOR 60 scf/stb, 90 scf/stb and 120 scf/stb with each tubing ID of 1.751-in, 2.441-in and 3.068-in. when GOR increase from 60 scf/stb to 90 scf/stb with tubing size 1,751-in the production rate increases form 1,874.80 bbl/d to 1,951.91 bbl/d and when GOR further increases to 120 scf/stb with the same tubing size the production rate goes up more to 2,029.32 bbl/d and upon this, production rate increases respectively with increasing GOR. And based on table 1 the production increases with larger tubing in which replacing 1.751-in to 2.441-in with GOR 60 scf/stb the production rate increases from 1,874.80 bbl/d to 2,805.77 bbl/d and when having 3.068-in with the same producing GOR, production rate increases more to 3,141.44 bbl/d and production rate increases respectively with increasing GOR and larger tubing size. According to Makinde (2017) producing GOR occurs due to reservoir pressure decline below the bubble point and gas saturation start to forming “GOR hill” at that time gas is not mobile yet however when critical gas saturation is reached gas can flow or gas evolution accelerates and producing GOR starts to increase rapidly. The result of sensitivity analysis proves that low increase of GOR 60 to 120 scf/stb cause the production rate to increase and the larger the tubing size of each case of GOR causes an increase in production rate therefore 3.068-in is the optimum tubing size based on higher production rate.

5. Conclusion and Recommendation

5.1. Conclusion

The conclusion of this study as the following:

a) The result of the sensitivity analysis reveals that low increase of GOR production add some value to the production of oil by increase the velocity of fluids from reservoir up to the well head. And no doubt that producing GOR occurs when reservoir pressure decline below the bubble point pressure;
   b) In addition, the result of tubing size selection indicates that larger tubing produce higher production rate in which caused by strong reservoir pressure to carry fluids along the tubing to the wellhead;
   c) And finally through this study by conducting simulation of PIPESIM software can provide new insight about the effect of GOR on production rate in two phase flow reservoir and the optimum tubing size selection.

5.2. Recommendation

The effect of Gas-Oil Ratio and the tubing size selection in this study which is done in Z field well X has limitation because only focus on higher production rate to be considered as the optimum tubing size. Therefore, suggestions for research in the future to put into consideration pressure loss across the

Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

perforation zone, pressure loss in the tubing, the lifetime production of the well, and correlations for solution gas drive reservoir.

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Vol.3, Issue.1, pp.11-18, 2022
Available online at: http://tljes.org/index.php/tljes/data

for Solution-Gas Drive Wells.

Appendix

Table 1. Data of nodal analysis Gas Oil Ratio variation with tubing ID 2.441-in

Stock-tank liquid at NA Point (stb/d)	Pressure at NA point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point
Operating Point	Operating Point	Inflow: 60 scf/sbbl	Inflow: 60 scf/sbbl	Inflow: 90 scf/sbbl	Inflow: 90 scf/sbbl	Inflow: 120 scf/sbbl	Inflow: 120 scf/sbbl	Outflow: ID 2.441 ins	Outflow: ID 2.441 ins
2.797,00	3.194,05	84,5296	3.977,77	84,5296	3.977,77	84,5296	3.977,77	16,1513	3.077,73
2.957,49	3.142,39	254,0587	3.932,85	264,0897	3.930,18	276,0927	3.926,98	461,0864	3.060,12
3.149,54	3.079,61	423,5879	3.887,47	443,6498	3.882,07	467,6559	3.875,59	1.128,49	3.068,69
		762,6462	3.795,27	802,7701	3.784,22	850,7822	3.770,97	1.795,89	3.103,10
		1.101,70	3.701,04	1.161,89	3.684,09	1.233,91	3.663,73	2.797,00	3.194,05
		1.440,76	3.604,66	1.521,01	3.581,51	1.617,03	3.553,64	2.957,49	3.142,39
		1.779,82	3.505,95	1.880,13	3.476,28	2.000,16	3.440,48	3.149,54	3.079,61
		2.118,88	3.404,75	2.239,25	3.368,19	2.383,29	3.323,98	3.981,65	3.211,26
		2.797,00	3.194,05	2.957,49	3.142,39	3.149,54	3.079,61	5.229,82	3.454,94
		3.503,99	2.960,74	3.644,42	2.912,49	3.812,47	2.853,85	6.477,98	3.761,55
		4.210,99	2.710,51	4.331,36	2.665,94	4.475,39	2.611,77	7.226,88	3.965,28
		4.917,98	2.439,06	5.018,29	2.398,49	5.138,32	2.349,18	8.350,23	4.308,66
		5.624,98	2.139,85	5.705,22	2.103,72	5.801,25	2.059,81	9.598,40	4.744,96
		6.331,97	1.802,07	6.392,16	1.770,99	6.464,17	1.733,24	10.347,30	5.028,77
		7.038,97	1.405,31	7.079,09	1.380,29	7.127,10	1.349,90	11.470,65	5.497,13
		7.392,46	1.172,00	7.422,56	1.150,61	7.458,56	1.124,65	12.219,55	5.831,95
		7.745,96	900,3311	7.766,02	883,3143	7.790,03	862,673	13.342,89	6.371,15
		8.099,46	561,2635	8.109,49	550,0457	8.121,49	536,463	14.466,24	6.956,18
		8.276,21	341,9958	8.281,22	334,934	8.287,22	326,4046	15.140,25	7.329,68
		8.452,96	40,031	8.452,96	40,031	8.452,96	40,031	16.151,27	7.955,54

Table 2. Data of nodal analysis tubing inside diameter variation with Gas-Oil Ratio 60 scf/STB

Stock-tank liquid at NA Point (stb/d)	Pressure at NA point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point
Operating Point	Operating Point	Inflow: 60 scf/sbbl	Inflow: 60 scf/sbbl	outflow: ID 1.751 ins	outflow: ID 1.751 ins	outflow: ID 2.441 ins	outflow: ID 2.441 ins	Outflow: ID 3.068 ins	Outflow: ID 3.068 ins
1.874,80	3.477,86	84,5277	3.977,77	6,6277	3.077,85	16,0644	3.078,71	29,4549	3.078,74
2.805,78	3.191,24	308,3118	3.918,38	305,5353	3.075,14	462,4183	3.060,16	1.274,25	3.047,34
3.141,44	3.082,28	532,0959	3.858,17	484,8799	3.090,55	1.131,95	3.068,81	3.141,44	3.082,28
		979,6641	3.735,20	753,8968	3.130,21	1.801,48	3.103,31	4.825,50	3.159,47
		1.427,23	3.608,55	1.202,26	3.234,76	2.805,78	3.191,24	5.835,94	3.224,29
		1.874,80	3.477,86	1.471,28	3.319,09	3.654,33	3.305,64	7.351,59	3.343,36
		2.340,29	3.337,23	1.874,80	3.477,86	4.163,46	3.381,25	8.362,03	3.436,87
		2.805,78	3.191,24	2.178,98	3.618,48	4.927,16	3.522,57	9.877,68	3.598,19
		3.141,44	3.082,28	2.635,26	3.868,18	5.436,29	3.620,35	11.393,34	3.783,08
		3.805,36	2.856,36	3.091,53	4.161,07	6.199,99	3.797,90	13.666,82	4.114,38
		4.469,27	2.614,09	3.365,30	4.356,64	6.963,69	3.985,49	14.677,26	4.270,84
		5.133,19	2.351,31	3.775,94	4.680,78	8.109,23	4.318,79	16.192,91	4.540,96
		5.797,11	2.061,72	4.232,22	5.082,46	9.382,06	4.740,11	17.708,57	4.830,32
		6.461,02	1.734,91	4.505,98	5.345,24	10.145,76	5.021,72	19.982,05	5.310,99
		7.124,94	1.351,28	4.916,63	5.770,05	11.291,31	5.482,99	21.497,70	5.663,81
		7.456,90	1.125,87	5.190,39	6.074,19	12.055,00	5.818,46	23.771,18	6.242,54
		7.788,85	863,6895	5.601,04	6.562,37	13.200,55	6.364,05	24.680,58	6.490,61
		8.120,81	537,2364	6.011,69	7.089,46	14.346,10	6.960,48	26.044,67	6.880,97
		8.286,79	327,0214	6.258,08	7.425,09	15.033,42	7.344,42	27.408,75	7.293,93
		8.452,77	40,4346	6.627,66	7.955,54	16.064,41	7.955,54	29.454,89	7.955,54

Vol.3, Issue.1, pp.11-18, 2022
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Table 3. Data of nodal analysis tubing inside diameter variation with Gas-Oil Ratio 90 scf/STB

Stock-tank liquid at NA Point	Pressure at NA point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point
Operating Point	Operating Point	Inflow: 90 scf/sbbl	Inflow: 90 scf/sbbl	outflow: ID 1.751 ins	outflow: ID 1.751 ins	outflow: ID 2.441 ins	outflow: ID 2.441 ins	Outflow: ID 3.068 ins	Outflow: ID 3.068 ins
1.951,91	3.454,91	84,5274	3.977,77	6,6847	3.059,78	16,1715	3.059,88	29,5866	3.060,45
2.957,51	3.142,39	317,9504	3.915,80	317,9209	3.020,21	486,7857	3.002,01	1.355,94	2.982,16
3.345,47	3.014,39	551,3734	3.852,95	504,6627	3.035,67	1.192,71	3.004,87	2.151,75	2.985,97
		1.018,22	3.724,44	784,7753	3.075,99	1.898,63	3.041,85	3.345,47	3.014,39
		1.485,07	3.591,89	1.251,63	3.189,29	2.957,51	3.142,39	5.024,91	3.099,38
		1.951,91	3.454,91	1.531,74	3.282,81	3.803,21	3.259,92	6.032,57	3.167,89
		2.454,71	3.301,86	1.951,91	3.454,91	4.310,62	3.343,16	7.544,06	3.297,61
		2.957,51	3.142,39	2.254,81	3.603,11	5.071,75	3.486,40	8.551,72	3.394,85
		3.345,47	3.014,39	2.709,15	3.859,31	6.340,30	3.773,75	10.063,21	3.563,09
		3.983,88	2.792,96	3.163,50	4.159,24	7.101,42	3.971,68	11.574,70	3.755,00
		4.622,29	2.555,53	3.436,10	4.358,59	8.243,11	4.309,07	13.841,94	4.089,20
		5.260,70	2.298,02	3.845,01	4.695,29	8.750,53	4.473,13	14.849,60	4.254,87
		5.899,11	2.014,27	4.299,36	5.100,14	9.511,66	4.747,80	16.361,09	4.523,62
		6.537,51	1.694,13	4.571,96	5.363,93	10.272,78	5.032,02	17.872,58	4.816,16
		7.175,92	1.318,47	4.980,87	5.788,45	11.414,47	5.496,51	20.139,82	5.313,82
		7.495,13	1.097,87	5.253,48	6.092,46	12.175,60	5.832,77	21.651,31	5.668,37
		7.814,33	841,4532	5.662,39	6.576,42	13.317,29	6.377,47	23.918,55	6.247,62
		8.133,54	522,6535	6.071,30	7.098,81	14.458,98	6.970,43	26.185,78	6.883,83
		8.293,14	317,9131	6.316,65	7.429,37	15.144,00	7.351,23	27.546,13	7.293,87
		8.452,74	40,5031	6.684,67	7.955,54	16.171,52	7.955,54	29.586,64	7.955,54

Table 5. Data of nodal analysis tubing inside diameter variation with Gas-Oil Ratio 120 scf/STB

Stock-tank liquid at NA Point (stb/d)	Pressure at NA point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point	Stock-tank liquid at NA point (STB/d)	Pressure at NA Point
Operating Point	Operating Point	Inflow: 120 scf/sbbl	Inflow: 120 scf/sbbl	outflow: ID 1.751 ins	outflow: ID 1.751 ins	outflow: ID 2.441 ins	outflow: ID 2.441 ins	Outflow: ID 3.068 ins	Outflow: ID 3.068 ins
2.029,32	3.431,74	84,5287	3.977,77	6,7047	3.041,23	16,1512	3.041,16	29,5339	3.041,01
3.147,66	3.080,23	327,6276	3.913,21	330,3232	2.949,66	517,1926	2.918,07	1.453,46	2.887,74
3.589,34	2.931,50	570,7265	3.847,70	524,4943	2.963,37	1.268,75	2.918,06	2.307,81	2.893,09
		813,83	3.781,18	815,7509	3.006,46	2.020,32	2.957,89	3.589,34	2.931,50
		1.056,92	3.713,61	1.301,18	3.135,31	3.147,66	3.080,23	5.249,79	3.025,02
		1.543,12	3.575,11	1.592,44	3.240,62	3.979,89	3.211,50	6.246,06	3.099,88
		2.029,32	3.431,74	2.029,32	3.431,74	4.479,23	3.302,50	7.740,47	3.238,93
		2.588,49	3.260,09	2.328,55	3.589,87	5.228,23	3.454,61	8.736,74	3.343,11
		3.147,66	3.080,23	2.777,38	3.858,67	5.727,57	3.568,99	10.231,15	3.520,85
		3.589,34	2.931,50	3.226,22	4.165,61	6.476,57	3.761,20	11.725,55	3.721,58
		4.197,28	2.715,55	3.495,53	4.367,08	7.225,58	3.964,91	13.967,16	4.072,21
		4.805,22	2.484,01	3.899,48	4.701,45	8.349,09	4.308,30	14.963,44	4.241,31
		5.413,16	2.232,93	4.348,32	5.113,13	9.597,43	4.744,61	16.457,84	4.513,98
		6.021,10	1.956,32	4.617,62	5.377,66	10.346,43	5.028,44	17.952,25	4.809,70
		6.629,04	1.644,32	5.021,58	5.801,18	11.469,94	5.496,84	20.193,86	5.302,27
		7.236,99	1.278,39	5.290,88	6.103,42	12.218,95	5.831,69	21.688,27	5.662,52
		7.844,93	814,2513	5.694,84	6.583,43	13.342,46	6.370,94	23.929,88	6.239,15
		8.148,90	504,7629	6.098,79	7.099,72	14.465,96	6.956,04	26.171,49	6.870,93
		8.300,88	306,6563	6.341,17	7.425,76	15.140,07	7.329,59	27.516,45	7.276,81
		8.452,87	40,2224	6.704,73	7.955,54	16.151,23	7.955,54	29.533,90	7.955,54