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APPRAISAL OF CONTINUOUS GAS LIFT SYSTEMS IN JAZAL 3 OIL FIELD / SYRIA

Annotation: *Continuous gas lift is a technology used by injecting a highly compressed gas to decrease the density of fluid column hence provide an additional lifting energy to increase the production performance of an oil well. The continuous gas lift system is evaluated based on the capabilities to overcome the well and reservoir condition Therefore, the objective of this paper is to distinguish the capabilities of continuous gas lift system in different type of well characteristics. An oil well Jazal-3 is used as the case study well where the simulation is evaluated through PIPESIM software. A model is developed to perform history matching with field production data to verify the results and to perform a sensitivity analysis on the liquid production. The result shows that the continuous gas lift application increases the liquid production rate up to 1125 m3/d.*

Key words: *continuous gas lift, artificial lift, PIPESIM.*

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ОЦЕНКА СИСТЕМ НЕПРЕРЫВНОГО ГАЗЛИФТА НА НЕФТЯНОМ МЕСТОРОЖДЕНИИ JAZAL 3 / СИРИЯ

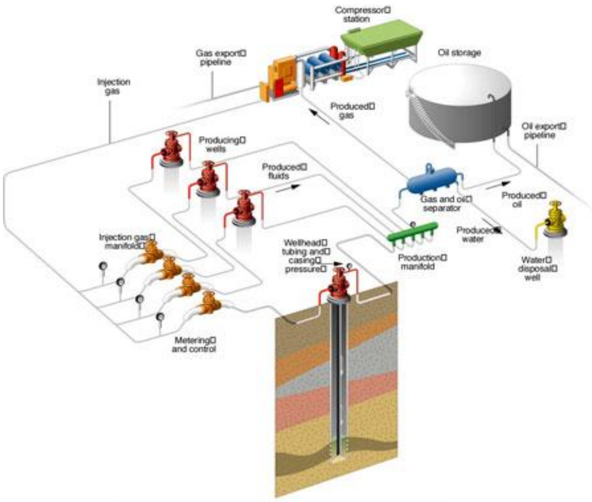
Аннотация: *Непрерывный газлифт - это технология, используемая путем закачки сильно сжатого газа для уменьшения плотности столба жидкости, что обеспечивает дополнительную подъемную энергию для повышения производительности нефтяной скважины. Система газлифта непрерывного действия оценивается на основе способности преодолевать состояние скважины и коллектора. Таким образом, целью данной статьи является определение возможностей системы газлифта непрерывного действия при различных типах характеристик скважины. Нефтяная скважина Джазал-3 используется в качестве примера скважины, где результаты моделирования оцениваются с помощью программного обеспечения PIPESIM. Модель разработана для выполнения сопоставления истории с данными добычи на месторождении, чтобы проверить результаты и выполнить анализ чувствительности добычи жидкости. Результат показывает, что применение газлифта непрерывного действия увеличивает дебит жидкости до 1125 м*^{3} */ сут.*

Ключевые слова: *непрерывный газлифт, искусственный лифт, PIPESIM.*

1. Gas Lift System:

Not all the oil wells start producing fluid naturally right after they put back online due to low Bottom Hole Pressure (BHP) which is insufficient to lift the fluid to the surface. At some point, the reservoir energy will not be sufficient to bring the reservoir fluid up to the surface because its energy is depleted. One way to help a well flow is to energize the reservoir fluid with a lighter fluid as the carrying fluid. In that case, the overall fluid density will drop which results in larger lift capability of the reservoir.

Gas lift is the form of artificial lift that most closely resembles the natural flow process. It may be treated as the extension of the natural flow process. In a naturally flowing well, as the fluid travels upward toward the surface, the fluid column pressure is reduced causing the gas to expand and move faster upward. Injected gas will help carrying some diluted liquid to the surface; however, if the gas velocity is not high enough, some liquid may start to fall off at some point near surface. Gas lift is frequently used in lifting water for the purpose of gas deliquefication. In this approach, a high-pressure gas is injected into the fluid column to reduce the flowing pressure gradient. In other words; gas lift is the process of supplementing additional gas (from an external source) to increase the gas-liquid ratio (GLR) resulting in reducing the flowing fluid density. This process considered an expansion of natural flow phase. Figure 1 shows the schematic of a typical gas lift system. Compared to the other artificial lift methods, gas lift is simpler, more adaptable, and more efficient at wide ranges of fluid production. There are two types of gas lift systems: continuous flow and intermittent flow. In both gas lift systems, high pressure natural gas is injected from the surface to lift formation fluid. Continuous flow gas, which is very similar to the natural flow, is the most common gas lift method in the industry. In this technique, injecting gas into the production conduit at the maximum depth depending on the injection pressure and well depth results in an increase in the formation gas liquid ratio. Hence, both the density of the produced fluid and flowing pressure gradient of the mixture decrease which lead to a lower bottomhole pressure. Lower bottomhole pressure improves wellbore productivity index. Intermittent gas lift operation is achieved by injecting gas at sufficient volume and pressure into the tubing at the point below the fluid column to lift the liquid to the surface. Intermittent flow is periodic displacement of liquid from the tubing by injection high pressure gas into the wellbore. The advantage of intermittent flow gas lift over the continue gas lift is periodic need of high pressure gas. On the other hand, since gas is injected intermittently over specific period of time, this method is not capable of producing at high volume rate compared to continuous flow gas lift. [6]



Artificial lift components. Courtesy: Schlumberger.

Figure 1. explain the gas lift production cycle and the surface equipment

2. Unloading Sequence [5]:

Figure 2 shows a well unloading process. Usually all valves are open at the initial condition, as depicted in Fig. 2a, due to high tubing pressures. The fluid in tubing has a pressure gradient Gs of static liquid column. When the gas enters the first (top) valve as shown in Fig. 2b, it creates a slug of liquid –gas mixture of less density in the tubing above the valve depth. Expansion of the slug pushes the liquid column above it to flow to the surface. It can also cause the liquid in the bottom hole to flow back to reservoir if no check valve is installed at the end of the tubing string. However, as the length of the light slug grows due to gas injection, the bottom-hole pressure will eventually decrease to below reservoir pressure, which causes inflow of reservoir fluid. When the tubing pressure at the depth of the first valve is low enough, the first valve should begin to close and the gas should be forced to the second valve as shown in Fig. 2c. Gas injection to the second valve will gasify the liquid in the tubing between the first and the second valve. This will further reduce bottom-hole pressure and cause more inflow.

By the time the slug reaches the depth of the first valve, the first valve should be closed, allowing more gas to be injected to the second valve. The same process should occur until the gas enters the main valve (Fig. 2d). The main valve (sometimes called the master valve or operating valve) is usually the lower most valve in the tubing string. It is an orifice type of valve that never closes. In continuous gas lift operations, once the well is fully unloaded and a steady-state flow is established, the main valve is the only valve open and in operation (Fig. 2e).

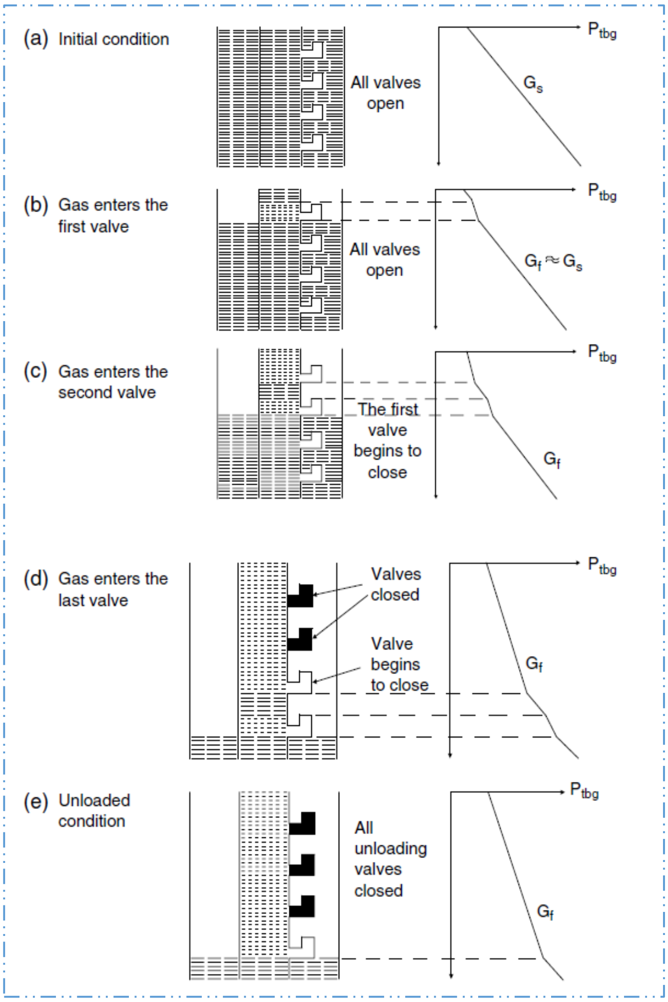


Figure 2. Well unloading sequence

3 . Building A Base Model:

Input data:

By reviewing the production data and test results, the following is revealed:

Table 1.

PVT data for Jazal 3 well

GOR	54	Sm^3 / sm^3
Oil density	38	API
Gas density	0.7082	
Oil viscosity	0.5659	c.P
Water Salinity	260000	PPM

Table 2.

IPR data for Jazal 3 well

Reservoir pressure	267.4	Bar
Reservoir temperature	111.39	C
Water cut	0	%
PI	13.08	Sm^3 / (d.bar)

3.1. the pressure Traverse plot for well:

The following diagram shows the pressure gradient values of the well length in the self-production period and we note the slight pressure difference between the reservoir pressure P_R and the downhole pressure of the well P_{WF}:

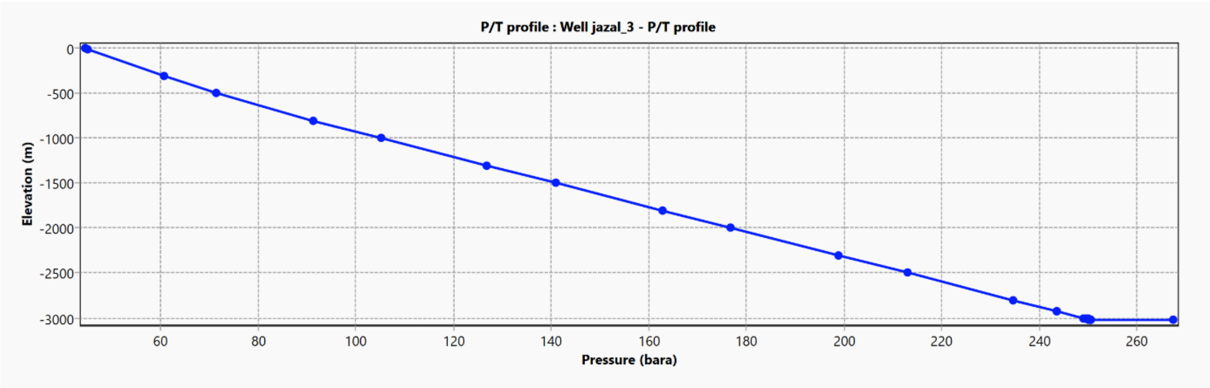
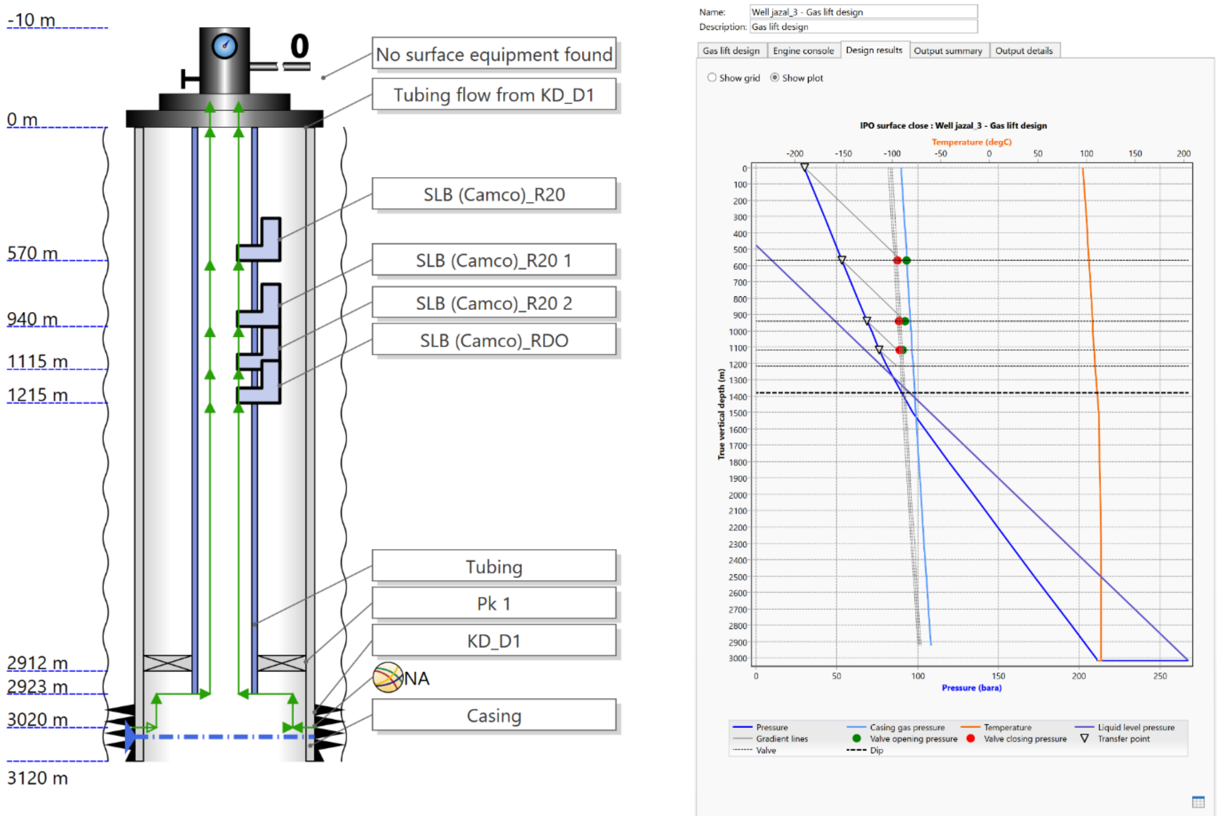


Figure 3. the pressure Traverse plot for well

3.2. Continuous Gas Lift Application:

The continuous gas lift is applied to the initial well jazal 3 with a total of four valves. The compressed gas from the surface flow through the casing annulus down the drill-string and enter the production tubing through three unloading valves located at 570 , 940 and 1115m and one operating valve at 1215 m. The illustration of the continuous gas lift down-hole design is shown in Figure 4



	Gas lift	Active	MD	Manufacturer	Series	Valve type	Port size	Ptro	St	Discharge coe...	DP to fully open
			m				mm	bara	bara		bara
1	SLB (Camco)_R20	✓	570.0321	SLB (Camco)	R20	IPO	9.525	76.98578		0.76	26.37934
2	SLB (Camco)_R20 1	✓	940.4123	SLB (Camco)	R20	IPO	9.525	77.02726		0.76	26.37934
3	SLB (Camco)_R20 2	✓	1115.67	SLB (Camco)	R20	IPO	9.525	76.6343		0.76	26.37934
4	SLB (Camco)_RDO	✓	1214.94	SLB (Camco)	RDO	Orifice	12.7			0.8	

Figure 4. Down-hole design of continuous gas lift application

The VLP curves with the application of continuous gas lift application intersect the IPR curve at a total liquid production of 700 m^3/d.

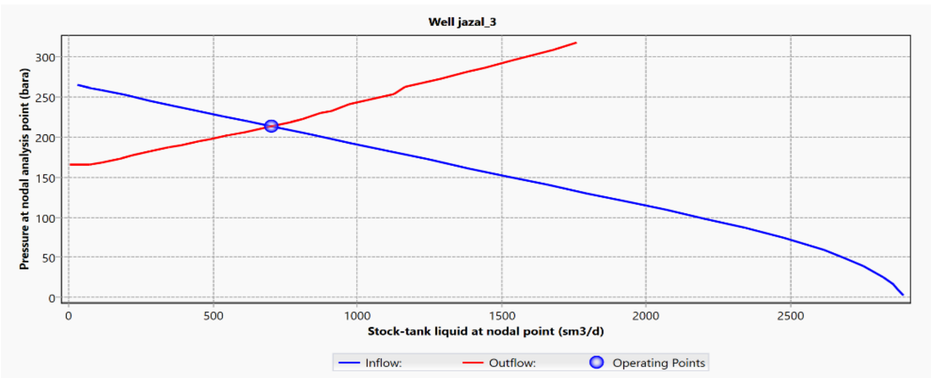


Figure 5. IPR VS VLP plot of continuous gas lift application

3.3. Pressure Traverse Plot after the Gas Lift installation:

Note the pressure difference obtained with the application of the gas lift process between the layer pressure P_R and the downhole pressure P_{WF}:

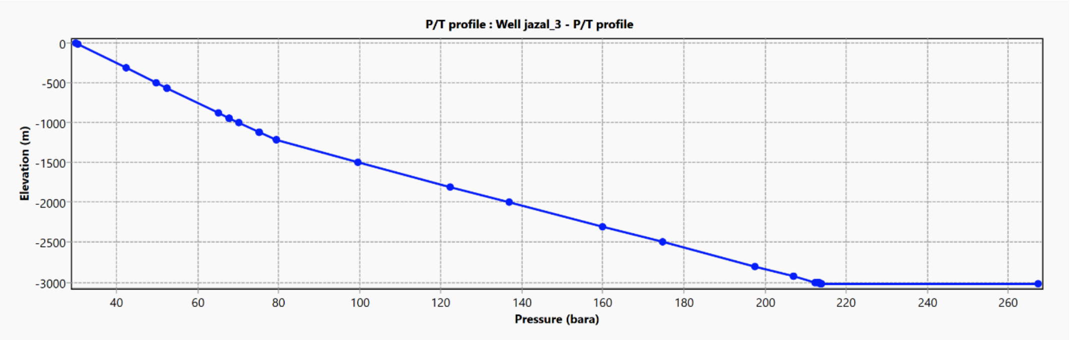


Figure 6. Pressure Traverse Plot after the Gas Lift installation

4. Continuous Gas Lift Optimization:

numerous of gas lift parameters are analyzed on the operating well in order to obtain an improvement in the production performance.

4.1. Gas Injection Rate:

The gas injection rate is the amount of compressed gas that is injected by the compressor from the surface down to the operating valve to reduce the density of the fluid column in the production tubing. Correspondingly, the increase of the gas injection rate increases the liquid production rate due to a lower density to be lifted up. An optimal injection rate that gives the highest production rate can be obtained by gradually increasing the gas injection rate wherein well Jazal-3, the gas injection rate is manipulated from 20,000 to 100,000 m^3/day. Figure 7 plots the analysis of the gas injection rate where Table 6 tabulates the results of the injection rate manipulation. It is observed that from 20,000 to 80,000 m^3/day, an increasing trend of liquid production rate is obtained from 654 to 730 m^3/day. However, on the gas injection rate of 100,000 m^3/day, the liquid production rate decreases to 729 m^3/day. This behavior happens when the gas injection is still increased after the optimum rate is reached [4]. Hence, a slippage between liquid and gas where the injected gas moves faster than the liquid phase hence dominating the upward movement of the fluid [3].

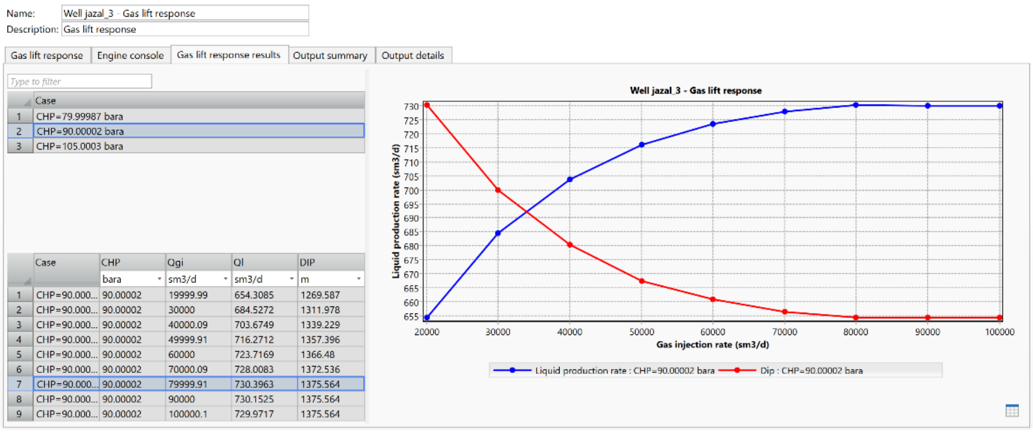


Figure 7. Gas injection rate sensitivity analysis

4.2. Gas Specific Gravity:

Gas specific gravity represents the density of the compressed gas used to be injected in the gas lift application. The range of the gas lift's gas specific gravity is between 0.55 to 1.0 sg hence the analysis is done by manipulating the specific gravity within the given range. The behavior of continuous gas lift application towards a variation of gas specific gravity injected is shown in Figure 8 while the numerical results are listed down in Table3. In accordance to the simulation, the denser the compressed gas injected results in a lower production rate. It occurs because the density of the compressed gas mixed with the high density of the fluid column into a new density to be produced once the compressed gas passes the operating valve. Hence, a denser compressed gas injected prevents an optimum density reduction in the fluid column.

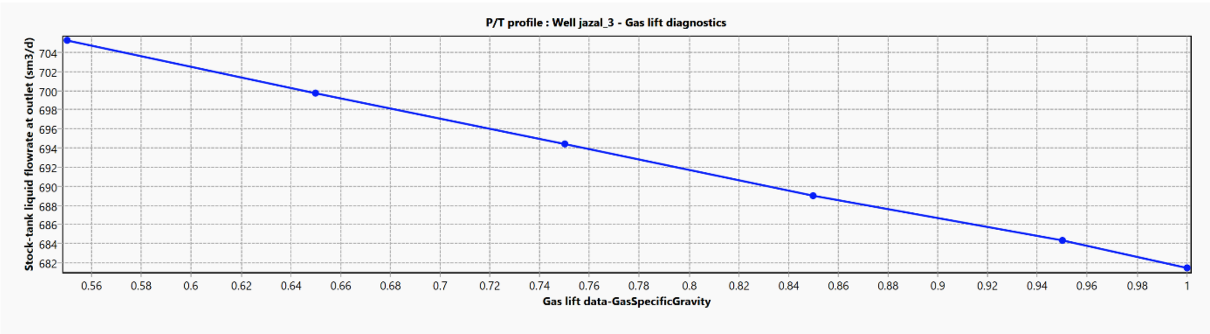


Figure 8. Gas specific gravity sensitivity analysis

Table 3.

Results of gas specific gravity sensitivity analysis

	Gas lift data-GasSpecificGravity	Stock-tank liquid flowrate at outlet
		sm3/d
1	0.55	705.2757
2	0.65	699.7421
3	0.75	694.4004
4	0.85	689.0286
5	0.95	684.348
6	1	681.4754

4.3. Wellhead Pressure:

Wellhead pressure or first node pressure is a pressure that exerted by the fluid at the top of the well. The main components of the wellheads are heads, spools and hanger of casing and tubing and suspension systems. The wellhead pressure needs to be combined with the hydrostatic pressure from the drill-string to obtain the flowing bottom-hole pressure which is used to determine the production rate of the well. In this analysis, the wellhead pressure is manipulated from 20 bar with a constant increment of 2 bar to 32 bar. Figure 9 plots the performance of continuous gas lift application towards the changes of wellhead pressure where the values are listed in Table 4. Accordingly, at the wellhead pressure of 20 bar, the well is producing 783 m^3/day of oil while only 684 m^3/day at the wellhead pressure of 32 bar. Hence, the higher the wellhead pressure produces a lower liquid production rate. The increase of the well head pressure lowers the drawdown pressure in the bottom-hole hence more pressure is required to lift the fluid [2].

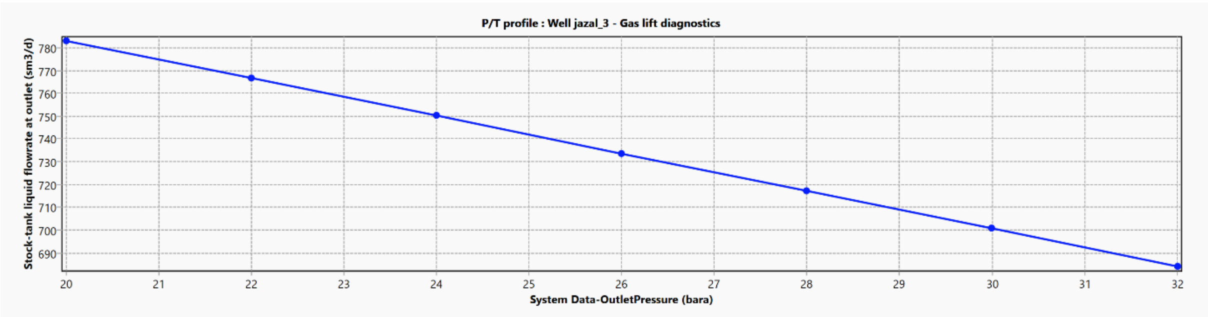


Figure 9. Wellhead pressure sensitivity analysis

Table 4.

Results of wellhead pressure sensitivity analysis

	System Data-OutletPressure	Stock-tank liquid flowrate at outlet
	bara	sm3/d
1	20.00031	783.0739
2	21.99979	766.6561
3	23.99996	750.1594
4	26.00013	733.7506
5	28.0003	717.3187
6	29.99978	700.693
7	31.99995	684.0444

4.4. tubing size:

for the inflow analysis, the objective was to construct the IPR curves for different tubing size factors to know how the tubing size is affecting the well performance if there was a is declining or increasing in this particular well. and assuming tubing size values of 2, 3, 3.5, 4 ID the Nodal Analysis was performed by PIPESIM software, the results were obtained as shown in Figure 10.

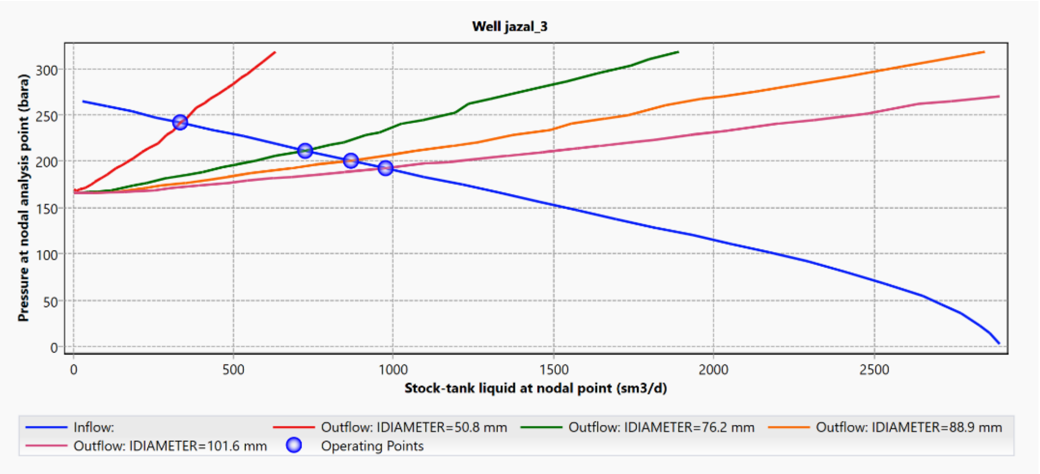


Figure 10. tubing size sensitivity analysis

Table 5.

Results of tubing size sensitivity analysis

	Tubing-InnerDiameter	Stock-tank liquid flowrate at outlet
	in	sm3/d
1	2	352.776
2	3	730.7984
3	3.5	871.428
4	4	977.6284

5. Sequential Optimization:

Sequential optimization is a method to obtain the optimized condition of a system by doing parameters analysis in sequence based where an optimum condition of each parameter analyzation is fixed before considering other parameters [1]. Hence, optimum manipulations from all the parameters are combined and the best outcome is achieved. The combination of the most suitable parameters is shown in Table 6 and plotted to Figure 11.

Table 6.

Sequential optimization parameters

Parameters	Values
Gas injection rate (m^3 / d)	80,000
Gas specific gravity (sg)	0.55
Wellhead pressure (bar)	20
tubing size (in)	4

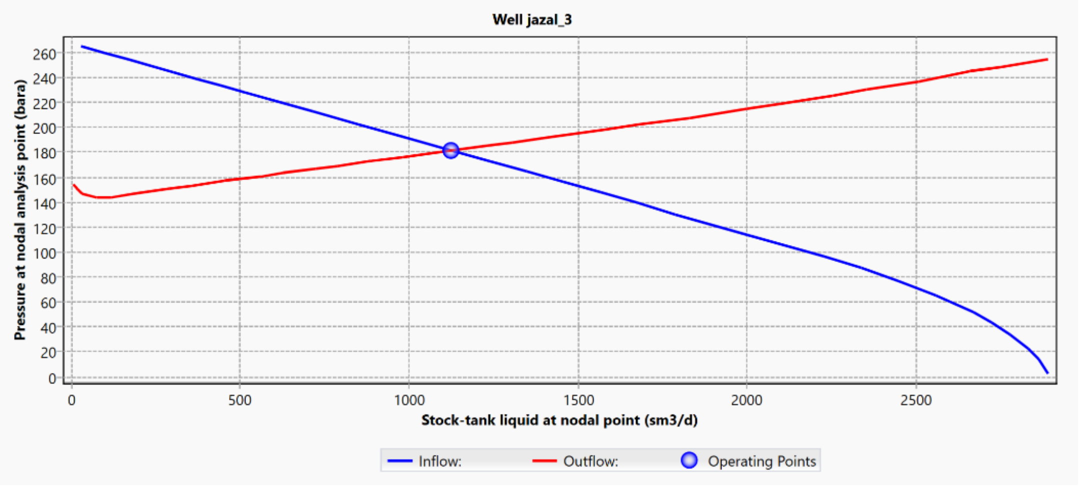


Figure (11) Sequential optimization parameters IPR VS VLP plot

Conclusion:

1. When the gas lift system was utilized, production from this well increased.

2. A deeper injection rate lets the compressed gas to reduce more of the fluid column's density hence higher production rate can be obtained.

3. The production rate increases with the gas injection rate as long as the rate is still below the upper limit where the slippage between gas and liquid occurs.

4. The least the specific gravity of the compressed gas injected gives a higher production rate.

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