PROFESSIONAL TECHNICAL PAPER
ONLINE PRESENTATION
24 - 25 OCTOBER 2020

Real-Time Gas Lift Well Optimization Using Surface Read Out (SRO) System in Bunyu Field

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Abstract. Gas lift optimization is required to sustain production in many oil fields. An optimum gas injection rate in each well is essential to maximize oil production by reducing the flowing bottom hole pressure (FBHP). This paper presents an effective method to optimize the production of gas lifted well by selecting an optimum gas injection rate using a real-time downhole data monitoring system.
The surface read out (SRO) system is used to evaluate the changes in FBHP to variation in gas injection rate in real-time. This system uses a downhole gauge that measures both temperature and pressure in the well from the surface to the perforation depth. When the downhole gauge reaches the perforation depth, a multi-rate test (MRT) is carried out with variation in gas injection rate to find the optimum rate.
This optimization method has been proven to be effective in determining the optimum gas injection rate and quickly increasing the well production rate. In addition, calibration of the well performance model based on actual gas lift performance curve (GLPC) from MRT result can provide more accurate production forecast.
Keyword: Gas Lift Optimization, Surface Read Out (SRO), Multi-Rate Test

1 Introduction

Gas lift is the main artificial lift system used in Pertamina EP Asset 5 Bunyu Field. There are 35 gas lifted wells from a total of 61 production wells, which contribute 2916 BOPD from the total production of 6000 BOPD or around 49%. This artificial lift system utilized compressed gas to be injected into the tubing string through the well annulus. As the gas flowing into the tubing, the pressure gradient in the tubing decrease, thus reducing the flowing bottom hole pressure (FBHP). Optimum well production will be achieved when the right amount of gas is injected into the well, which yields the lowest FBHP within the well production system. Therefore, optimizing the gas injection rate of a gas lifted well is one of major objective for Bunyu Field production team.

Recent developments include the utilization of a real-time downhole data monitoring system that captures the changing behavior in FBHP. The system is combined with a multi-rate test (MRT) program with variation in gas injection rate to demonstrate the relationship between liquid production rate and the injected gas rate which usually termed as the gas lift performance curve (GLPC). The curve illustrates how production is affected by the variation in the gas injection rate. This method has been used in Bunyu Field to determine the optimum gas injection rate and improving the oil production of gas lifted wells.

2 Methodology

2.1 Well Performance Model

Well performance can be analyzed with nodal analysis. It is a systematic analysis of the complete well system from the reservoir to the sand face, across the perforations or bottom hole, up to the surface including any restrictions such as downhole valve, the surface choke, the flowline and to the separator. In this paper, the single well nodal analysis is used to describe the performance of the well based on the Inflow Performance Relationship (IPR) and the Vertical Lift Performance (VLP). The bottom hole is selected as the node where IPR represents the deliverability of the reservoir to the well and the VLP represents the tubing flow performance from the bottom of the well to the surface. For optimization purpose in gas lifted well model, the IPR and the VLP should match with the actual production data test by selecting the fittest well flow correlation.

Well B-X1 and B-X2 were selected as an example to illustrate the gas lift optimization process. Both well were installed with 7 gas lift valves, with B-X1 had been producing around 150 to 200 Bopd and B-X2 around 100 to 120 Bopd. The surface facility constraint in Bunyu Field was also considered, where the maximum upstream pressure in the gas injection network line was below 380 Psia. Initially, a multiphase steady-state simulator was used to predict the well performance before any intervention to the well is made. Figure 1 shows the flowchart used to create a gas lifted well model with reliable nodal analysis to represent the current and future performance of the well. Then, a sensitivity study on GLPC was carried out to give an idea on how the well production rate would behave with different gas injection rate. However, this preliminary analysis was highly dependent on the accuracy of well data, selection of well flow correlation and the understanding on the entire well production system.

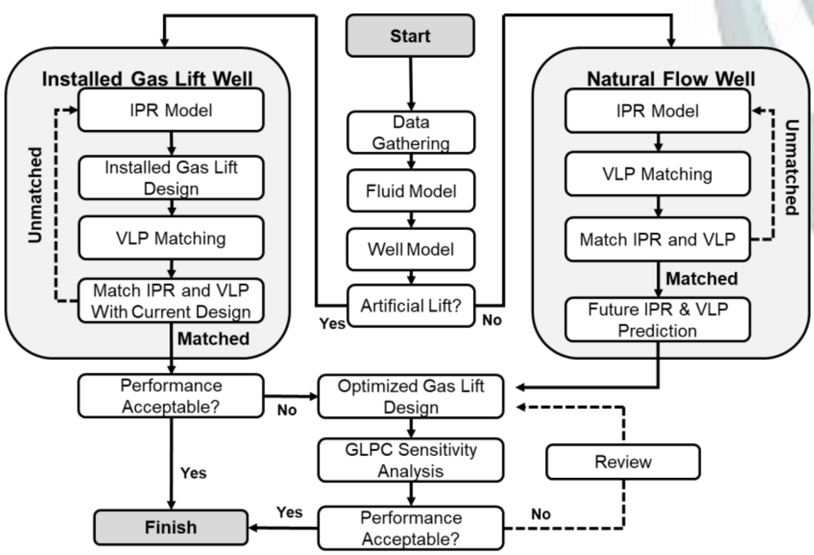

Figure 1 – Well Modelling Flowchart

2.2 Surface Read Out (SRO) System

The SRO system is divided into surface and downhole sub-system. The surface equipment consisted of mobile truck-mounted wireline unit, surface pressure control, hydraulic power pack unit and SRO monitoring device. The downhole equipment consisted of downhole pressure and temperature gauge, knuckle joint and wireline cable that can transmit data in real-time. The downhole gauge is run into the well by the wireline cable and the pressure-temperature data are monitored in real-time from the surface. The system is equipped with a Pressure Transient Analysis software for data processing.

In a regular basis, FBHP survey program is executed to monitor the temperature and pressure from the surface to the perforation depth of the well using the SRO system. The purposes of the FBHP survey are:

- To check the point of injection or operating valve depth.
- Measure the bottom hole pressure.
- Investigate anomaly within the well system such as tubing or casing leaked.
- Validate well flow correlation used within the well model based on the pressure profile.

2.3 Multi-Rate Test (MRT)

Production performance of a well is evaluated regularly with production test. During FBHP survey with SRO system, the production test is also conducted to acquire both bottom hole pressure and oil production rate data. These data are required for nodal analysis validation within the steady-state simulator. For gas lift well optimization, there is an extra requirement to conduct more production tests with various injection gas rate which called multi-rate test (MRT).

MRT program requires four or more gas lift rates to be selected within the normal operating range (Chia and Hussain, 1999). The test normally starts from low to high gas injection rate. Sufficient time of production test is allowed after each gas injection rate increment to stabilize the well flow. A graphical plot is made between the production data and the gas injection rate which represents the actual GLPC of the well. This analysis then is combined with the lowest bottom hole pressure observed from SRO system to determine the optimum gas injection rate.

3 Result and Discussion

3.1 Well B-X1 Optimization

Well B-X1 nodal analysis is illustrated in Figure 2. Without gas injection, the well may not flow naturally as the line VLP 1 is not intersecting the IPR line. With 300 Mscfd injected gas, the well is producing 180 Bopd as shown by the operating point, where line VLP 2 intersect the IPR. This operating point matched with the actual production data test from FBHP survey using the Hagedorn & Brown well flow correlation.

Based on the GLPC sensitivity analysis model in Figure 3, additional gas injection rate to more than 300 Mscfd may increase oil production. In general, oil production rate would increase as the gas injection rate is increased, until it reaches the optimum rate, after which the oil production rate decline as more gas injected causing excessive friction losses. The optimum gas lift injection rate is affected by several factors such as tubing size, formation fluid properties, water cut and GOR.

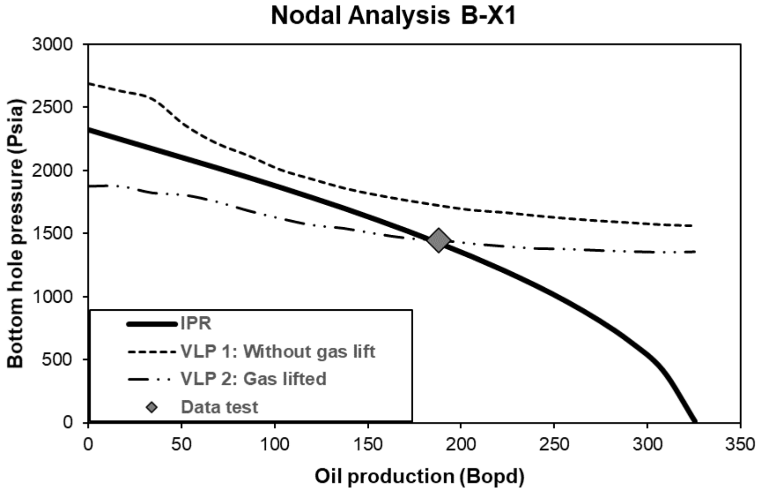

Figure 2 – Nodal analysis well B-X1. VLP 1: without gas injection. VLP 2: with gas injection

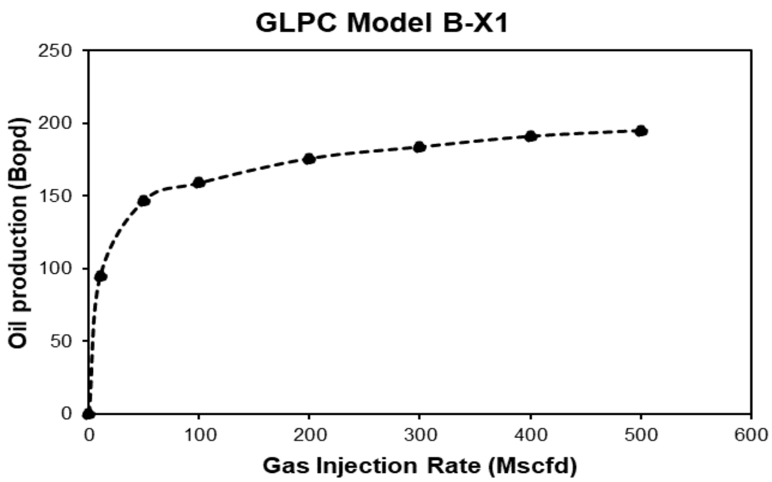

Figure 3 – Gas lift performance curve B-X1 model from steady-state

The MRT program was initiated with 4 different gas injection rates from 150 Mscfd, 250 Mscfd, 350 Mscfd and 450 Mscfd. Between gas injection rate interval from 150 to 250 Mscfd, the FBHP declined from 928 Psia to 880 Psia in average as shown in Figure 4. Adjusting gas injection rate to 350 and 450 Mscfd causing FBHP rose to 940 Psia in average. This result was followed by increasing oil production to

260 Bopd at the first two gas injection intervals, then declined to 160 Bopd in the last intervals as shown by the actual GLPC in Figure 5.

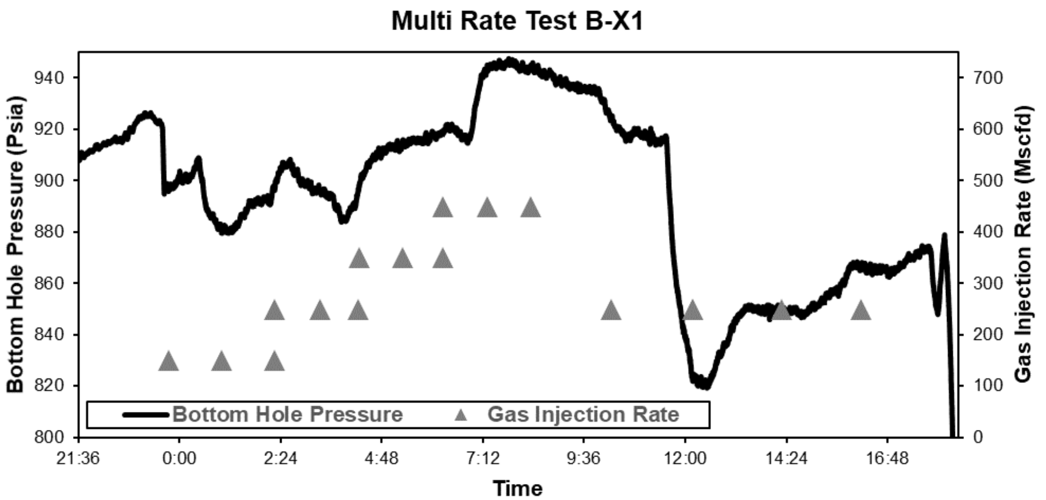

Figure 4 – FBHP responses to different gas injection rates during multi rate test in B-X1

It can be concluded that the optimum gas injection rate is ranging from 250 to 300 Mscfd where the lowest FBHP and the highest oil production rate were observed. At the end of the MRT program, the gas injection rate was adjusted to its optimum at 250 Mscfd which resulted in FBHP reduction to around 840 Psia and increasing oil production to 270 Bopd.

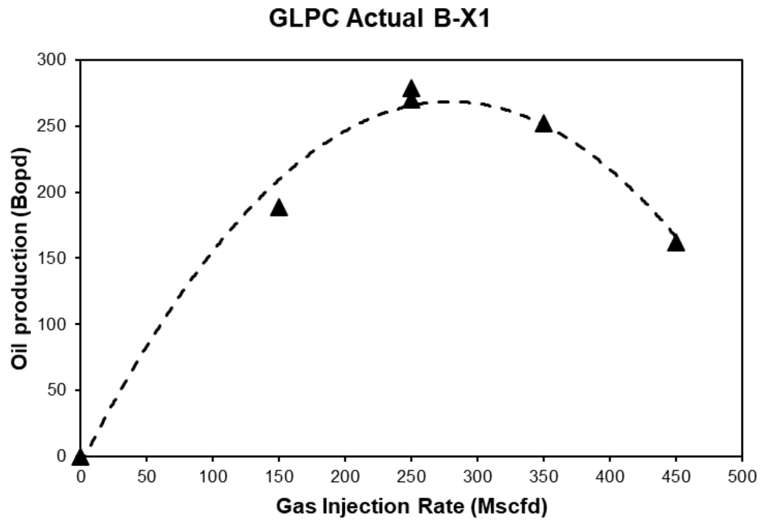

Figure 5 – Actual B-X1 GLPC from MRT program

3.2 Well B-X2 Optimization

Similar procedure was initiated for well B-X2 optimization process. Figure 6 shows the nodal analysis for well B-X2, with operating point at 90 Bopd. This operating point matched with the actual production data test from FBHP survey using the Hagedorn & Brown well flow correlation. Based on the GLPC sensitivity analysis model in Figure 7, an additional gas injection rate to more than 150 Mscfd may increase oil production.

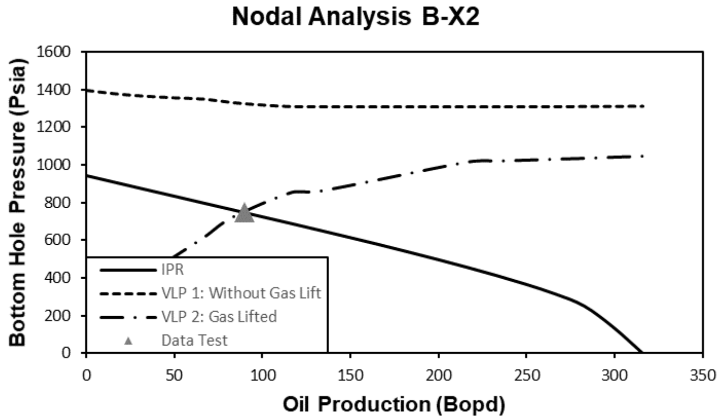

Figure 6 – Nodal analysis well B-X2. VLP 1: without gas injection. VLP 2: with gas injection

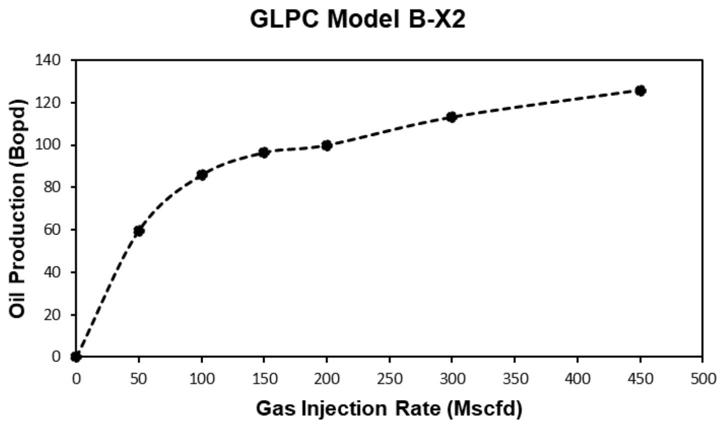

Figure 7 – Gas lift performance curve B-X2 model from steady-state simulator

During the MRT program, well B-X2 showed different response compared to well B-X1, where the oil production was decreasing with gas injection rate increment. This response was followed by increasing FBHP observed in the SRO system. Between gas injection rate interval from 150 to 450 Mscfd, the FBHP increased from 985 Psia to 995 Psia in average as shown in Figure 8. Oil production decreased from 115 Bopd to 60 Bopd during the same interval as shown by the actual GLPC in Figure 9. It can be concluded from the SRO data survey and MRT result that the optimum gas injection rate is around 150 Mscfd. The GLPC actual is more reliable to be used for optimum gas injection rate selection. Therefore, it was used to correct the GLPC model in the steady-state simulator for future performance prediction.

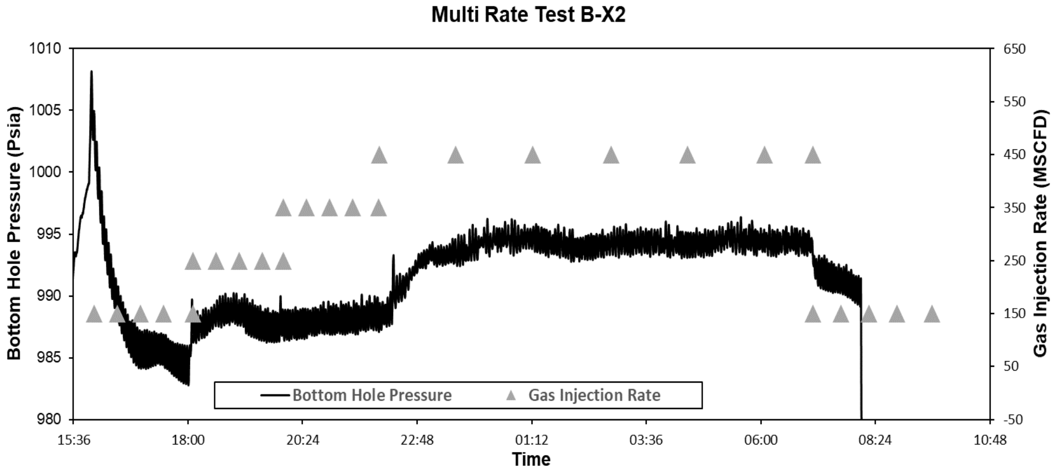

Figure 8 – FBHP responses to different gas injection rates during multi rate test in B-X2

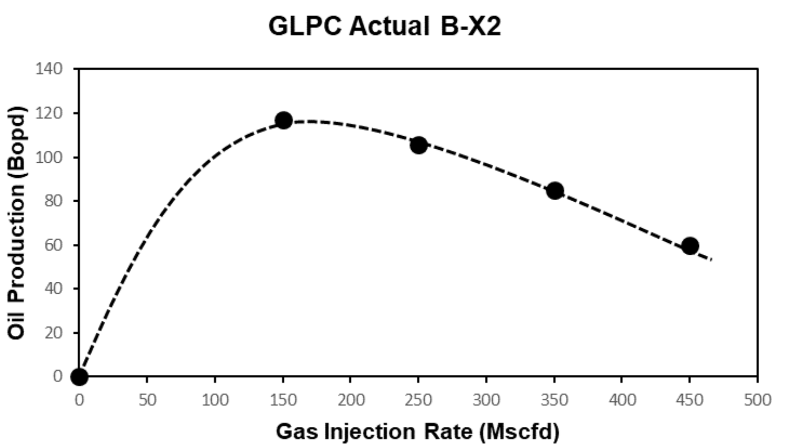

Figure 9 – Actual B-X2 GLPC from MRT program

4 Conclusion

1. Production of gas lifted well is optimized by selecting an optimum gas injection rate using Surface Read Out (SRO) system and Multi-Rate Test (MRT) program in a real-time condition.
2. The optimum gas injection rate is selected based on the lowest flowing bottom hole pressure observed by the SRO system and the highest oil production rate during the MRT program.
3. The method presented in this paper has been proven effective in determining the optimum gas injection rate within the normal operating condition considering surface facility constraint in Bunyu Field.
4. Gas lift performance curve (GLPC) actual from the MRT program is more reliable and can be used to correct the GLPC model generated in the steady-state simulator.

References

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