UTILIZING NEW GAS LIFT ALGORITHM TO ACCURATELY DETERMINE GAS INJECTION RATE

Dustin Sandidge
Apergy

ABSTRACT

Problem being addressed: Determining optimized gas injection rate for gas lifted wells to maximize lift efficiency.

Challenges: While Gas Lift is the most natural artificial lift method, ever-changing surface and downhole conditions cause significant inefficiencies. The changing conditions require frequent adjustments to surface-injected gas rates to maintain the most efficient lifting gradient. If the proper adjustments are not made, these inefficiencies may hinder production and increase lease operating expenses.

Solution: By using the proprietary gas lift hunting algorithm, optimal gas injections rates are determined by the magnitude in the bottom hole pressure drawdown with use of a permeant down hole gauge. Through continuous and proportional rate adjustment, the algorithm learns from previous setpoint deltas and tests against the inferred optimal rate, as well as changing conditions.

Results: In under-injection scenarios, the gas lift algorithm can accelerate the recovery of oil by up to 10 percent, regardless of the well's position on its natural decline.

In over-injecting scenarios, wells can maintain oil production rates while using up to 50 percent lift gas.

Both results can be successfully achieved with few engineering hours, manually calculating or modeling well performance curves to determine inferred optimal rate. Gas injection has become a key process in the range of modern solutions that exists within artificial lift operations, and its importance is predicted to increase.

However, although the popularity of gas lift is increasing, the majority of the world's gas-assisted wells operate in a nonoptimal state, and considerable challenges exist around the accurate and effective monitoring and measurement of process efficiency.

INTRODUCTION

Determining the optimal gas injection rate (GIR) for a well has traditionally been a relatively inaccurate procedure involving consideration of the correlations between, for example, nodal analysis from user inputs to establish calculations and infrequent GIR updates. Such procedures have been based on a "set it, test it and change it frequently" methodology. This type of method has clear limitations, given that more accurate methods have been created to achieve much greater returns.

FINDING OPTIMAL GAS INJECTION RATES

The aim of artificial lift processes is to promote bottomhole pressure (BHP) drawdown to encourage the inflow of production from the reservoir. The focus of the new gas lift algorithm is to establish the correlation between the rate of gas injection and the BHP drawdown to determine the optimal GIR at any point in the life of the well.

The parabola in Figure 1 indicates the optimal rate of gas injection in a well is equivalent to the maximum achievable drawdown level, which is at the vertex of the parabola. To the left of the parabola's vertex, where the GIR is lower than optimal, an increase in BHP is created, leading to liquid loading of the well.

This situation indicates density in the well is not decreasing at a high enough point to continue optimal inflow production from the reservoir.

The right-hand side of the parabola vertex indicates what happens when there is an over injection of gas beyond the optimal rate, which creates friction issues. In this scenario, too much energy is being deployed in the well; tubing, casing, wellhead and reservoir pressures are being backed up and the BHP cannot be reduced.

A further complication is well conditions change constantly, so the algorithm has been designed to search for the optimal GIR and continually test it to ensure the well is operating within the optimal range at all times.

INCREASED ACCURACY OF GAS INJECTION RATES

The gas lift algorithm is set up at the surface, as part of a well site controller, with a BHP gauge in the bottom of the well transmitting data via cabling, which is linked into the artificial lift controller. The reading from the pressure gauge enables the monitoring of the BHP and the managing of the GIR through the control valve, which increases or decreases the GIR.

The algorithm is based on a user-defined operational framework and works through the frequent and proportional adjustment of GIR based on the magnitude of BHP drawdown derived from trailing set-point results. Two injection points are established initially, with the difference between those points referred to as the pressure differential Δ1. A further adjustment to the algorithm sets a third point to establish the pressure differential Δ2. If the decline rate for Δ2 is less than for Δ1, this indicates the GIR is moving away from the optimal rate rather than toward it and corrective action is required.

Figure 2 shows the algorithm working in a practical sense in a well in the Permian Basin. Here, the kickoff GIR is established at 14,158 cu. m/d (500,000 cf/d) and is increased at a rate of 1,415.8 cu. m/d (50,000 cf/d) over 24 hours to establish the pressure differential Δ1. A second BHP differential is then created as Δ2 and the two differentials are compared. If the drawdown for Δ2 is greater than for Δ1, then gas injection will be increased because it indicates the well is transferring from a liquid-loading scenario toward optimal GIR. If a decrease in drawdown is observed between Δ2 and Δ1, the injection rate is moving in the wrong direction and the process needs to be inverted with a proportional change in the adjustment magnitude from 1,415.8 cu. m/d to 708 cu. m/d (25,000 cf/d). The focus at all times is on chasing the curve to maintain an injection rate as near to the vertex as possible.

By monitoring BHP drawdown, the algorithm searches for the optimal GIR to stimulate maximum inflow. Once the optimal rate is located, the algorithm will then slightly adjust the GIR to ensure that as well conditions change, the gas-lift system continues at optimal performance.

CASE STUDY #1: UNDER-INJECTION SCENARIO

An operator installed a Gas Lift system to produce a maturing, low GLR well in the Permian Basin.
For the first 90 days, the well production was highly sporadic, causing low and inefficient rates.
The operator decided to manually-adjust the gas injection rates for the next 90 days, based on historical data. Production rates were less sporadic and the well began producing 90 BOPD. With ever-changing well conditions, however, the operator found it difficult to monitor the BHP drawdown to determine the optimal gas injection rate.

The operator started utilizing the gas lift algorithm to determine the optimal gas injection rate and discovered he was under-injecting the well. The gas lift algorithm continually monitored the BHP drawdown and adjusted the GIR to ensure optimal injection rates as well conditions changed.
Within one month of using the gas lift algorithm, the BOPD and BFPD significantly increased.

By increasing the gas injection rate, the well began producing and average production increase of 73 BOPD, as shown in Figure 3.

CASE STUDY #2: OVER-INJECTION SCENARIO

An operator installed a Gas Lift system to produce a maturing, high GLR well in the Permian Basin. For the first 90 days, the well production was at a steep decline. The operator decided to manually adjust the gas injection rates for the next 60 days, based on historical data. Production rates began to stabilize along the decline cure and the well started producing 253 BOPD with a GIR of 750 mcfd. With ever-changing well conditions, however, the operator found it difficult to monitor the BHP drawdown to determine the optimal gas injection rate.

The operator started utilizing the gas lift algorithm to determine the optimal gas injection rate and discovered he was over-injecting the well. The gas lift algorithm continually monitored the BHP drawdown and adjusted the GIR to ensure optimal injection rates as well conditions changed. Within approximately one month of using the gas lift algorithm, the GIR significantly decreased while maintaining production rates.

By decreasing the gas injection rate, the well decreased the lift gas by 42% to 433 mcfd while maintain the BOPD along the steady decline curve, as shown in Figure 4. This saved the operator significantly in lift gas and operating costs.

ACKNOWLEDGEMENTS

The author would like to acknowledge the Apergy Engineering Team; Jay Taylor, Business Analyst; Girmay Amdemariam, Business Development Manager; and Andrew McConomy, Director of Sales and Operations, for the development and launch of Bloodhound™ (Patent Pending).

REFERENCES

Sandidge, D. (2018, August 1). Hart Energy. *Chasing the Curve*. Retrieved February 14, 2019 from https://www.epmag.com/chasing-curve-1710901#p=full

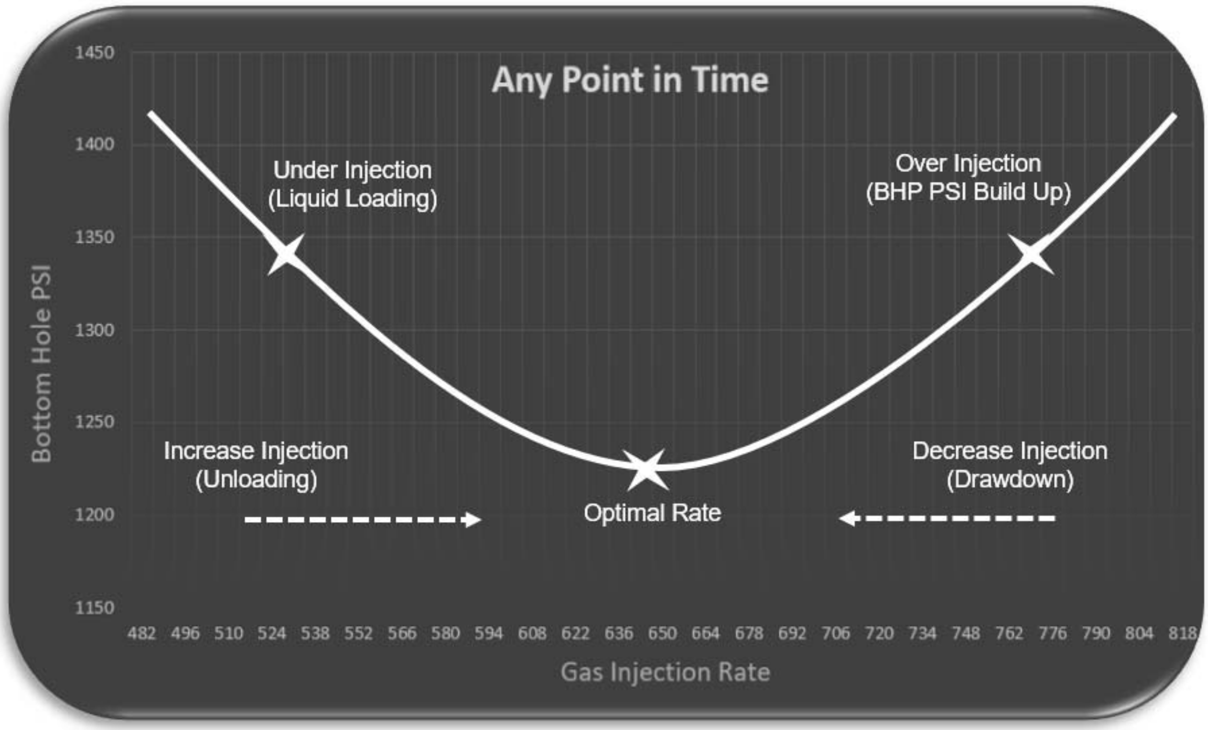

Figure 1: The graph depicts the magnitude of BHP drawdown in relation to optimal GIR.

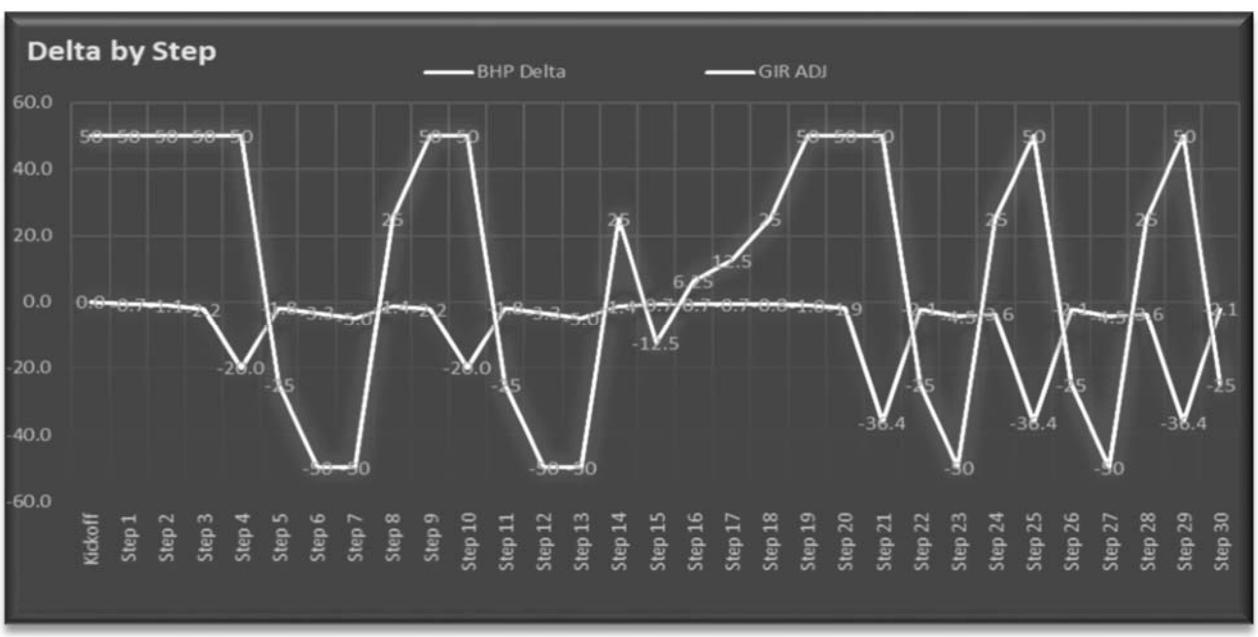

Figure 2: The graph shows the gas lift algorithm working in a well in the Permian Basin.

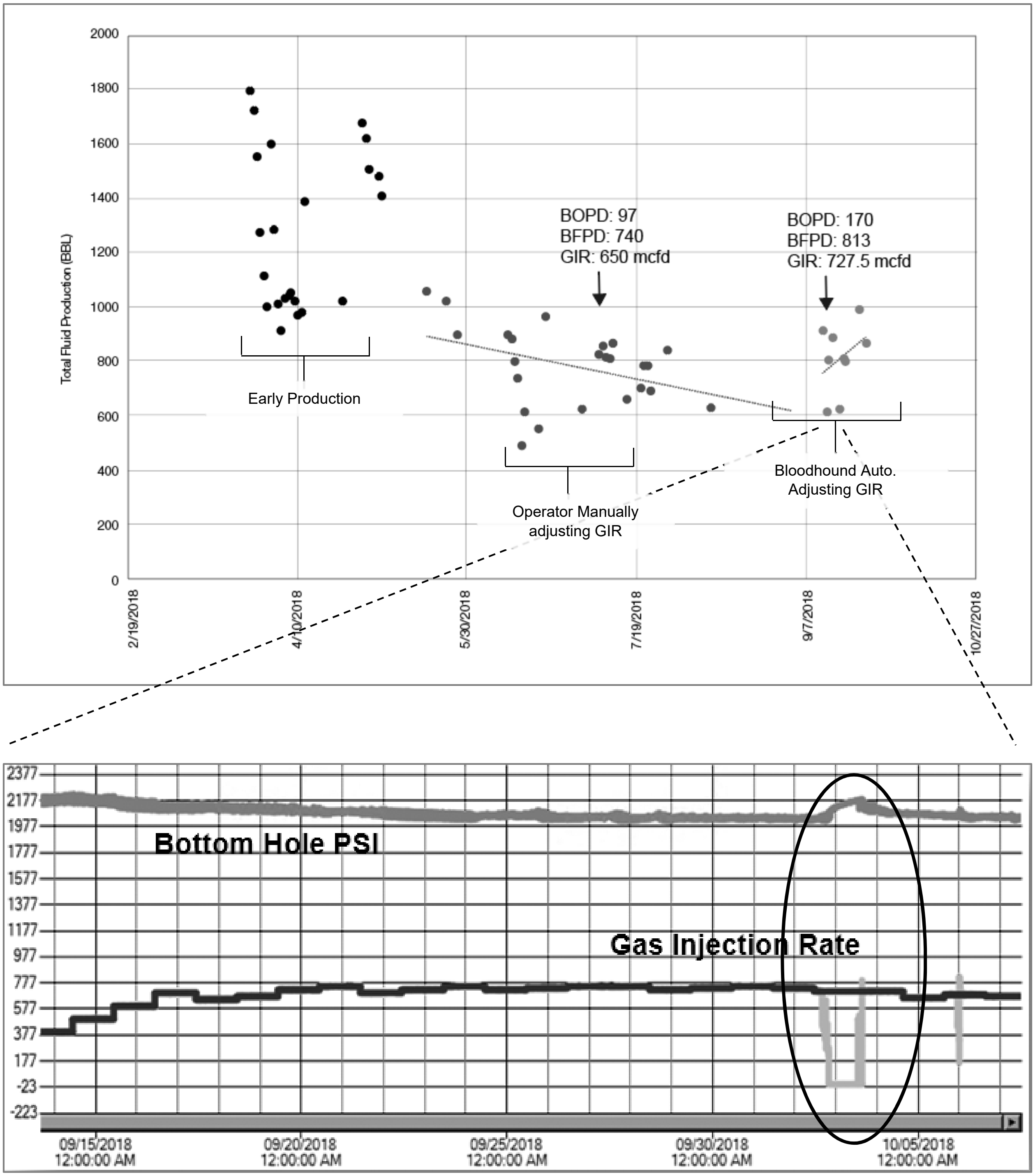

Figure 3: The graph shows the average production increase of 73 BOPD
with utilization of gas lift algorithm.

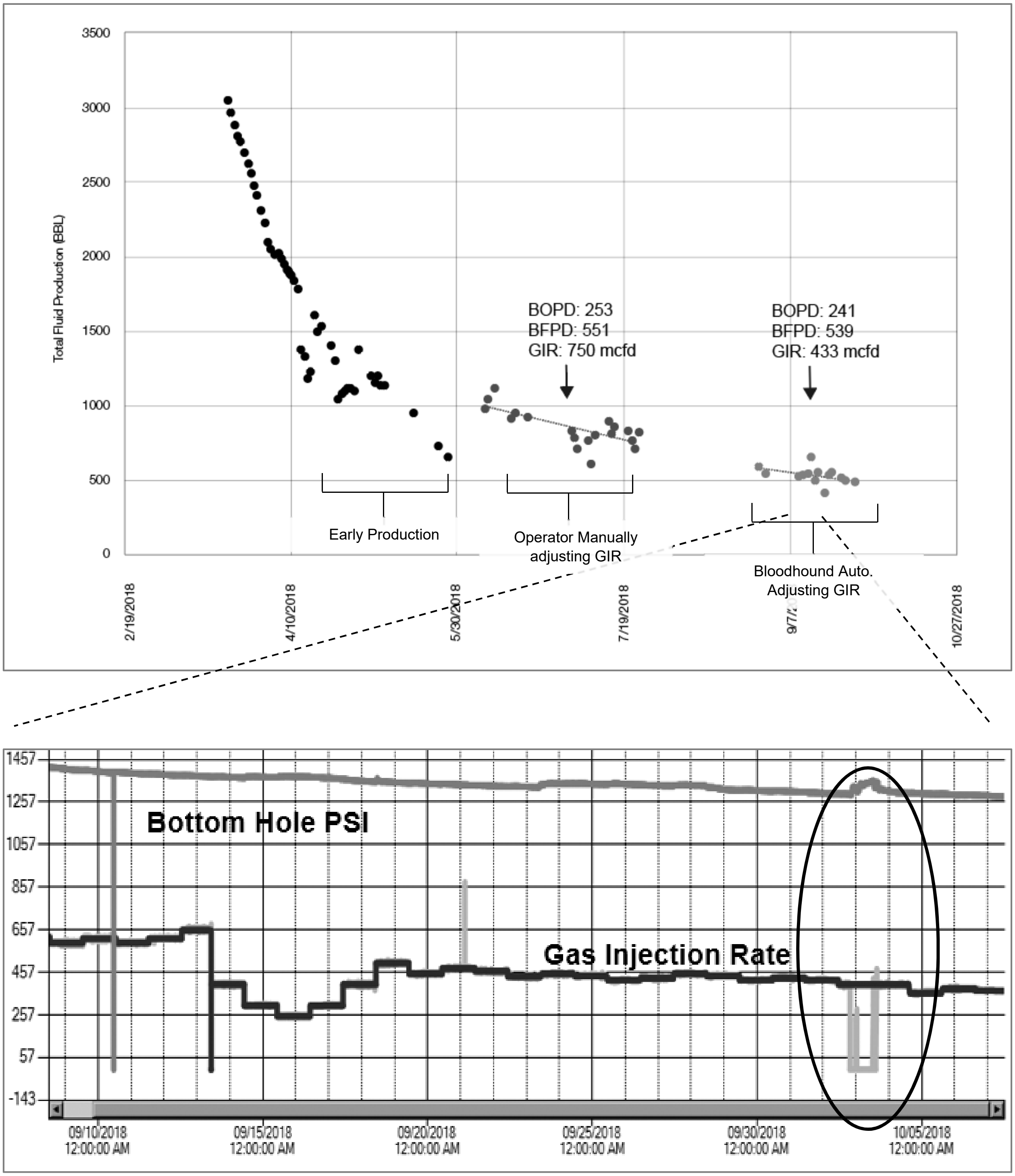

Figure 4: The graph shows a 43% decrease in lift gas while maintaining BOPD along the decline curve with utilization of gas lift algorithm.