

## Maximizing Oil Well Production in the Buzurgan Oil Field with an Optimized Gas Lift: A Simulation Analysis Utilizing PROSPER

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**Abstract:** As oil wells age, reservoir pressure decreases, impacting natural flow. The study aims to maximize oil production using the gas lift technique, emphasizing efficiency, stability, and reservoir management. With 1.3 trillion barrels of proven reserves, crude oil remains crucial for industrialized nations. Artificial lift, especially gas lift, is employed when natural pressure becomes inadequate. The goal of the study was to increase the amount of oil produced from an aged oil well (MB21), whose production was dropping as a result of large water cuts of up to 25% and a diminishing reservoir pressure. To increase the production rate of this well, we have used the gas lift technique. The oil production rate for well (MB21) increased from 0 STB/day to 396.6 STB/day using the gas lift technique and an injection rate of 8 MMscf/day. This well was successfully "reborn" by the gas lift technique, which turned it from being a non-producing oil wells back into active one. The outcomes show how effectively the gas lift optimization strategy works to increase production from aging oil wells that are experiencing significant water cuts and diminishing reservoir pressure. This method worked successfully for bringing inactive wells back to life and increasing their useful life.

**Keywords:** Oil Recovery; Primary Recovery; Artificial Lift; Gas Lift Method; Prosper System; Well Performance Optimization; Buzurgan Oil Field.

## 1. Introduction

It is typical for reservoir pressure to be insufficient in the oil and gas production industry to raise the produced liquids to the surface. Artificial lifting techniques are utilized in these situations to enhance the liquid's flow rate. Gas lifts and pumps are the two main types of artificial buoyancy technologies that are now accessible. As one of the most important artificial buoyancy technologies, gas lifts are the subject of this study (1). Around the world, gas lift devices are extensively employed to increase oil production rates. Most oil and gas wells throughout the world suffer a common challenge: they are unable to attain commercial production rates without help due to insufficient reservoir pressure to transport fluids to surface. This might happen due to low starting reservoir pressure or a progressive pressure reduction over time. To compensate for the absence of natural energy in these formations, artificial lift systems are installed in the wells. Artificial lift systems are installed in wells with commercially viable reserves and sufficient permeability to allow fluid migration into the borehole. However, these formations often lack the pressure needed to naturally transport fluids to the surface. Artificial elevators fill this gap by providing the energy needed to lift liquids. Gas lift is an important artificial lift technique in which high-pressure gas is injected into a well casing to lift fluids either continuously or periodically. Gas injection relieves the fluid, allowing pressure to be forced from the wellbore to the surface. Gas lift is ideal for offshore wells where docking space is limited and

equipment is mostly located in the bottom hole (2). In the modern oil and gas business, well designs are frequently modeled and evaluated using specialist software known as PROSPER. PROSPER is a well performance, design, and optimization program that allows production or reservoir engineers to forecast pipe and tube temperatures, hydraulics, and other critical parameters quickly and accurately. The sensitivity calculation features in the program make it easier to optimize existing well designs and assess the prospective implications of future system parameter changes (3). To better understand and assess gas lift systems, PROSPER software is used to generate a simulated well-developed model that represents the gas lift technology and naturally runs well. This well model includes important well features, including PVT (pressure, volume, temperature) information, reservoir characteristics, downhole equipment specifications, and production statistics (4).

In this research, we will investigate gas lift systems in depth, including their concepts, operating processes, design concerns, and performance optimization strategies. Using PROSPER software, we want to create a well-simulated model that gives significant insights into the behavior and performance of gas lift systems and naturally flowing wells. This study aims to improve the knowledge and implementation of gas lift technology in the oil and gas sector, eventually increasing production efficiency and optimizing hydrocarbon recovery.

## 2. Literature Review

Several researchers have worked on designing gas lift systems, such as Chacín in 1994, who examined intermittent lift systems in the oil production sector, with a focus on the Maracaibo Lake region. The study highlights the necessity of these systems as an economical and effective means of extracting fluid from reservoirs. The study emphasizes the importance of selecting the best intermittent lift system, considering factors like operating valve design, unloading valve spacing, and equipment selection. It provides simplified methods to evaluate and compare three intermittent schemes: piston stroke (PL), continuous throttle stroke (CL), and intermittent throttle stroke (IL). The study also identifies three distinctive stages of the intermittent lifting process, namely, gas injection, plug development, plug rise and slip past the plug, flow generation (blow-off), and plug formation. Cycle time is considered the most crucial controlling parameter, maximizing the performance of the intermittent lift system. The study suggests that effective intermittent lift system design may not require full mechanistic models, suggesting simpler methods that can yield positive results (5). However, in 2012, Shafaei et al. emphasized its efficiency and cost-effectiveness by leveraging improved CO<sub>2</sub> solubility in brine and higher well column pressure. The paper proposes a new method for injecting CO<sub>2</sub> into tubing that employs gas-lift valves and enhances CO<sub>2</sub> solubility in water. Because CO<sub>2</sub> is more soluble in brine and the well column creates more pressure, this design is more efficient. It also cuts CO<sub>2</sub> compression and water pumping costs. Connections, sources, sinks, and junction nodes make up the process model. The findings show that the proposed design improves CO<sub>2</sub> solubility in the brine while necessitating somewhat more compression energy due to the decreased temperature gradient. When employed, however, the overall energy consumed for compression and pumping is significantly reduced. The authors conclude that reverse gas-lift technology is a more efficient and cost-effective method of CO<sub>2</sub> storage, resulting in improved CO<sub>2</sub> dissolution into brine, cheaper compression and pumping costs, and the prospect of quick field-scale CO<sub>2</sub> geological storage deployment (6).

The authors conclude that reverse gas-lift technology is a more efficient and cost-effective method of CO<sub>2</sub> storage, resulting in improved CO<sub>2</sub> dissolution into brine, cheaper compression and pumping costs, and the prospect of quick field-scale CO<sub>2</sub> geological storage deployment. The study sought to develop an Electrical Submersible Pump (ESP) and a continuous gas lift system to address deteriorating productivity. They used Pipesim (7) software to develop a mathematical model that

predicted fluid production rates under various operating situations. The research looked at aspects such as the inflow performance relationship, pressure-volume-temperature data, downhole equipment, and temperature profiles. The researchers discovered that ESP and gas lift procedures were useful for optimizing oil and gas output. They utilized field data from existing wells that had halted owing to low reservoir pressure to assess the performance of each strategy.

### 3. Methodology

#### 3.1 Study area

The field of study. Figure 1. The Buzurgan oil field is near the Iraq-Iran border in the southern province of Missan. Baghdad is located around 550 kilometers northeast of Basra, which is roughly 175 km north. The Buzurgan structure extends 40 km<sup>2</sup> in length and 7 km<sup>2</sup> in width, covering a total area of 394 km<sup>2</sup>, with a NW-SE trend that runs parallel to the Zagros Mountains range.

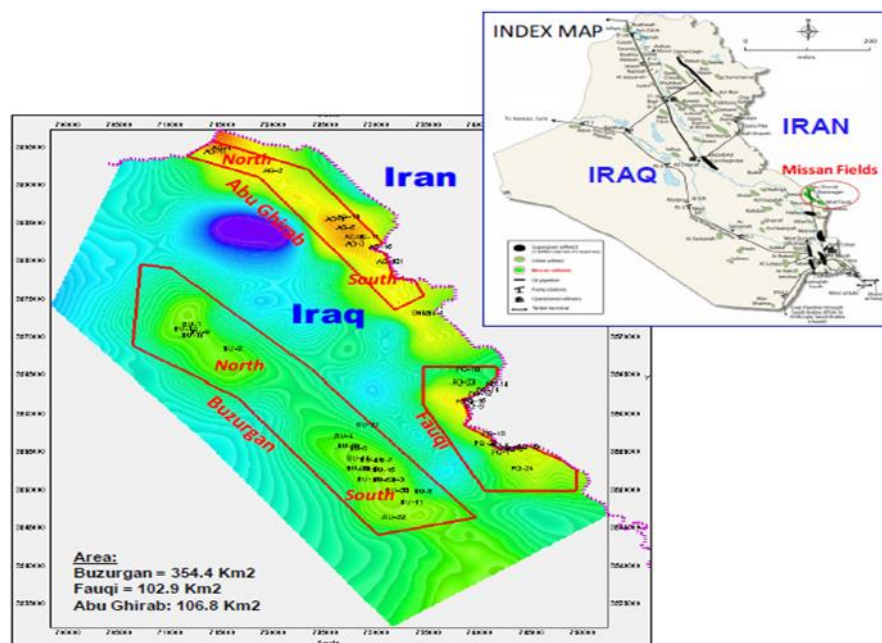


Figure 1: The Missan Oil Fields' base Map 3-D Seismic Survey Indicates Where the Research Is (BU) From (Aldarraji et al, 2019)

#### 3.2 Data Collection Area

Data for this study were collected from a well-known MB21, which was in the southern Iraqi oil field of Buzurgan and had insufficient reservoir pressure. Data from Well MB21 in the Buzurgan oil field, southern Iraq, indicate that low reservoir pressure hinders natural flow. To optimize production, gas lift is employed, injecting compressed gas into the wellbore to reduce hydrostatic pressure and lower bottom-hole pressure (BHP). This ensures efficient fluid flow while maintaining BHP above critical levels to prevent reservoir damage and production inefficiencies. Gas lift effectively allows liquid to reach the surface without damaging the tank or causing inefficient output.

#### 3.3 Data for the software

We collected data on fluid properties, reservoir characteristics, well geometry and completion, production history, and gas lift system information to create a well model using the gas lift technique. This data includes pressure-volume-temperature (PVT) information, inflow performance relationship (IPR) inputs, and downhole details such as deviation surveys and equipment configurations. All data

were organized according to the input requirements of the PROSPER simulator, with all units specified in field units.

### 3.4 Utilized Software

This study utilized Prosper, a tool that accurately predicts output characteristics. PROSPER can enhance the current system by providing tools to evaluate each well's performance critically. The application creates well models that consider all factors such as well configuration, fluid properties (PVT), multiphase VLP correlation, and various IPR models. PROSPER creates a trustworthy model by changing PVT, multiphase flow correlations, and IPR to match observed field data, allowing for forecast accuracy.

### 3.5 Working Procedure for Well Model Setup

The study involved a methodical approach to model setup, working from left to right via Prosper's main screen. The main screen is organized in the following order:

#### 3.5.1 Building a Base Model for the Well (MB21)

##### 3.5.1.1 PVT input data

Fluid characteristics as a function of pressure and temperature must be precisely predicted to forecast variations in pressure and temperature from the reservoir along the well bore and flow line tube. The application needs the whole set of PVT data to precisely define the fluid properties and perform computations, as can be seen in Figure 2. Building a Base Model for the Well (MB21)

Fluid characteristics, as a function of pressure and temperature, must be accurately predicted to model variations in pressure and temperature along the reservoir, wellbore, and flow line. The application needs the whole set of PVT data to precisely define the fluid properties and perform computations.

The screenshot displays the 'PVT - INPUT DATA (gas lift new 1.Out) (Oil - Black Oil)' window. At the top, there is a menu bar with buttons: Done, Cancel, Tables, Match Data, Regression, Correlations, Calculate, Save, Open, Composition, and Help. Below the menu bar, there is a 'Use Tables' checkbox and an 'Export' button. The main area is divided into three sections: 'Input Parameters', 'Correlations', and 'Impurities'.  
 - **Input Parameters:** A table with four rows: Solution GOR (545, scf/STB), Oil Gravity (22.5, API), Gas Gravity (0.9122, sp. gravity), and Water Salinity (80000, ppm).  
 - **Correlations:** Two rows: Pb. Rs, Bo (Glaso) and Oil Viscosity (Beal et al).  
 - **Impurities:** A table with three rows: Mole Percent H2S (0, percent), Mole Percent CO2 (0, percent), and Mole Percent N2 (0, percent).

Figure 2: PVT Input Data

##### 3.5.1.2 IPR (inflow performance relationship)

The reservoir inlet flow Inflow performance relationship (IPR) curve combines bottom hole pressure and flow rate in the well. In this case, the software uses the Darcy model for pressures above the bubble point. The IPR curve helps us see how the bottom hole pressure affects the flow rate. In this scenario, the well has natural flow conditions with a pressure of 4400 psia and no water cut, as demonstrated by the IPR curve.

### 3.5.1.3 Equipment Data

This section includes the following subsections:

- A. Deviation Survey
- B. Surface Equipment
- C. Downhole Equipment
- D. Geothermal Gradient
- E. Average Heat Capacities

#### A. Deviation Survey

Choose a few depth locations from the well deviation survey that represent notable deviation changes. For each measured depth (MD), provide a pair of data points together with the associated actual vertical depth (TVD). You can input up to twenty pairs of data points as in figure (3).

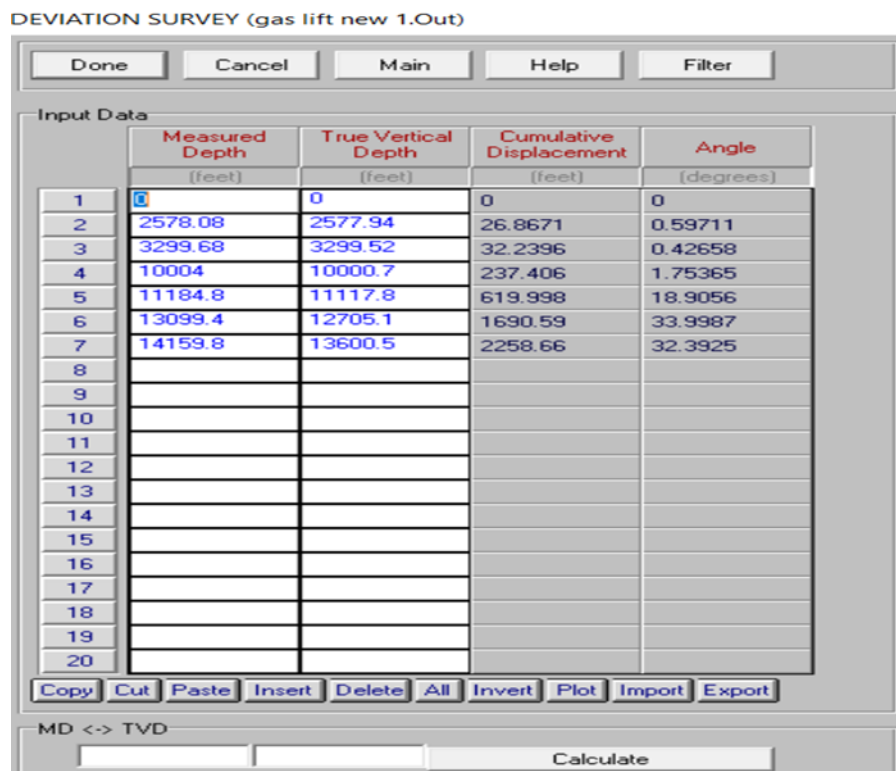


Figure 3: Deviation Survey for Well (MB21)

#### B. Downhole Equipment

Downhole Equipment could be inserted in its own section as in Figure (4).

DOWNHOLE EQUIPMENT (gas lift new 1.Out)

Input Data										
Label	Type	Measured Depth (feet)	Tubing Inside Diameter (inches)	Tubing Inside Roughness (inches)	Tubing Outside Diameter (inches)	Tubing Outside Roughness (inches)	Casing Inside Diameter (inches)	Casing Inside Roughness (inches)	Rate Multiplier	
1	Xmas Tree	0								
2	Tubing	10306.2	4.5	0.0006					1	
3	Casing	13336.5					9.625	0.0006	1	
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

Figure 4: Downhole Equipment for well (MB21)

**C. Geothermal gradient**

PROSPER uses the geothermal gradient as in Figure 5 to calculate formation temperatures at various depths. A rough profile can be computed using linear interpolation by inputting surface and reservoir temperature values, as well as the appropriate depth readings. A minimum of two data points is necessary for accurate interpolation. In addition, the geothermal gradient and overall heat transfer coefficient are considered when forecasting the formation's temperature distribution

GEOTHERMAL GRADIENT (gas lift new 1.Out)

Input Data		
Formation Measured Depth (feet)	Formation Temperature (deg F)	Overall Heat Transfer Coefficient (BTU/h/ft <sup>2</sup> /F)
1	60	8
2	14159.8	
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

Figure 5: Geothermal Gradient

### D. Average Heat Capacity

Average Heat Capacity could be inserted in its own section to have more accurate results as in Figure (6).

Average Heat Capacities (gas lift new 1.Out)

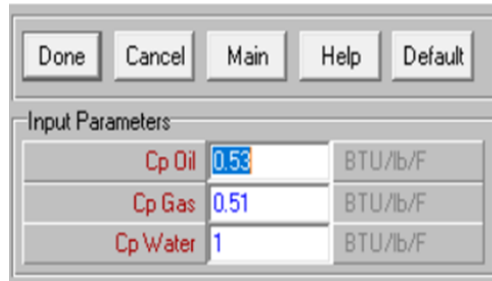


Figure 6: Average Heat Capacity

### 3.6 Building a gas lift Design

The following results need to be input for the well simulation in PROSPER, as in Figure 7, when doing a gas lift design:

- The ideal rates of lift gas injection and output.
- Use the deepest feasible gas injection.
- Maximum depth and number of valves for unloading.

GasLift Design - NEW WELL (gas lift new 1.Out)

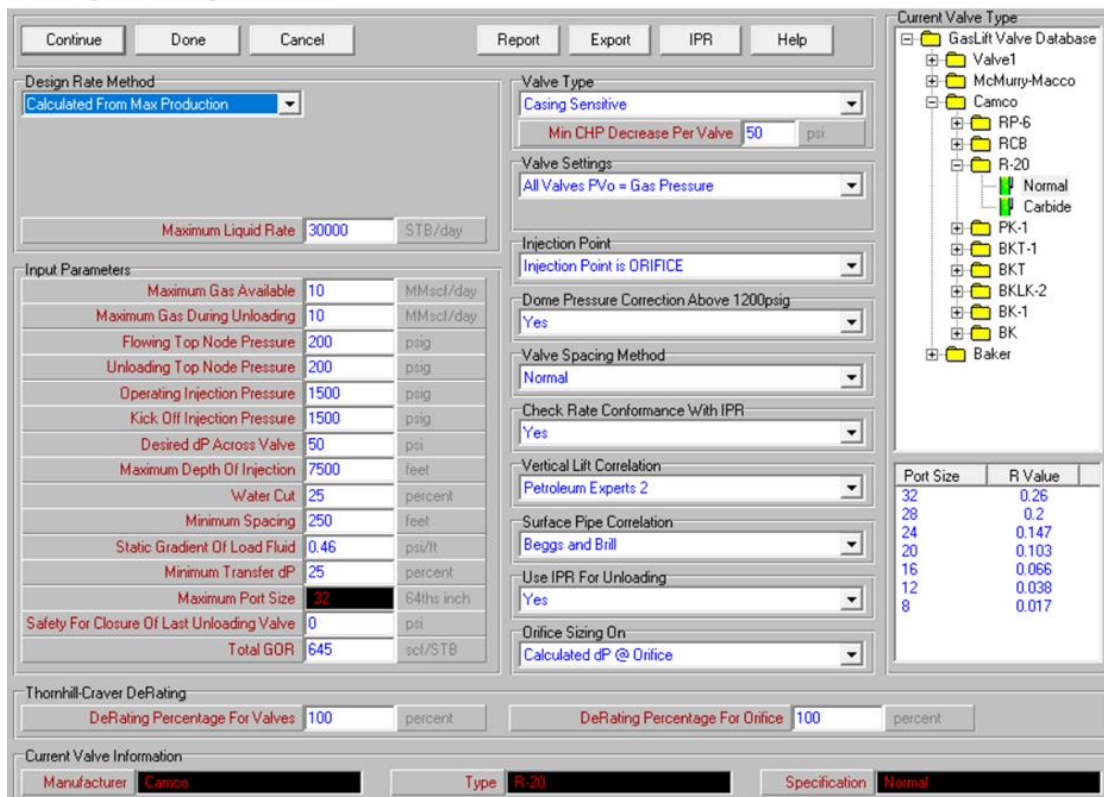


Figure 7: Gas Lift Input Window for Well (MB21)

When designing a gas lift, the performance curves shown below are used to determine the amount of oil the design should aim for. Obviously, wells with a higher water cut will require more gas injections to compensate for the well's relatively low gas production due to formation oil or lack of solution gas.

In turn, injecting too much gas reduces productivity and simultaneously increases operating costs. Therefore, determining the correct gas injection rate is important to achieve maximum oil production. The best results are obtained by plotting the Continuous Gas Lifter Performance Curve (GLPC). Figure 8 shows the relationship between gas injection rate and oil production.

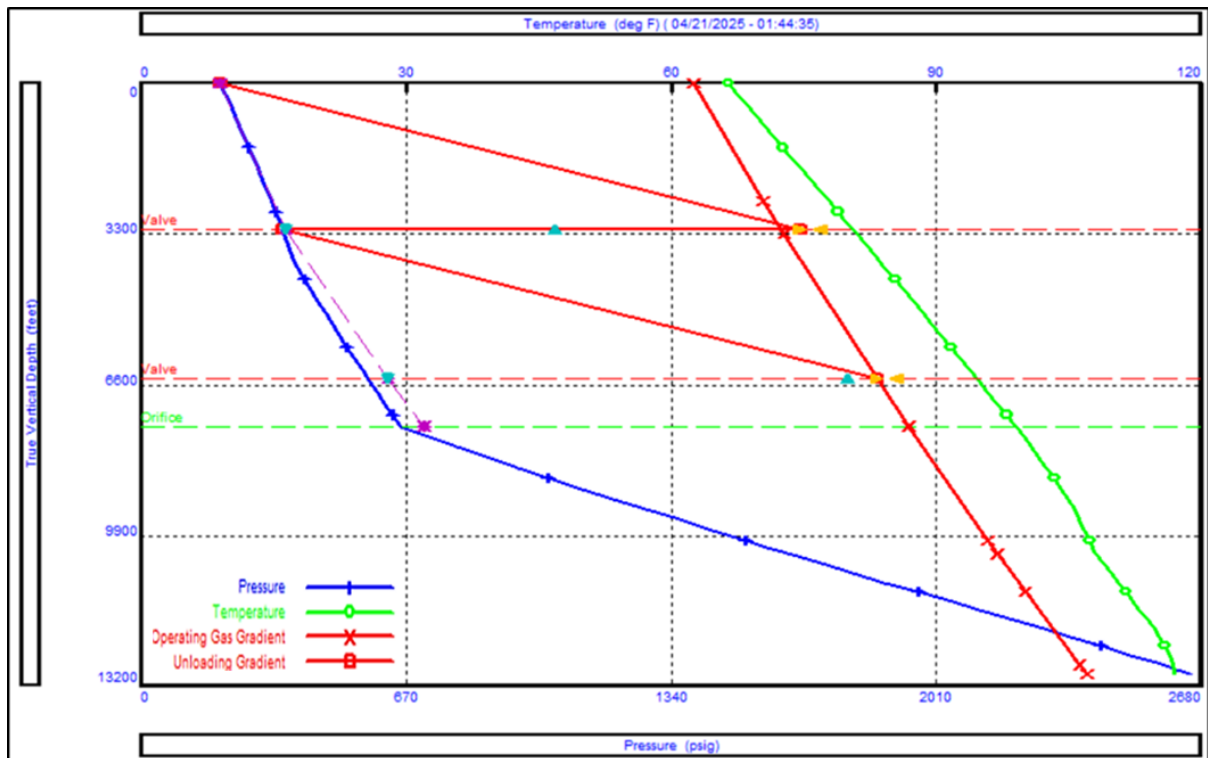


Figure 8: Continues Gas Lift Performance Curve (GLPC)

#### 4. Findings and Discussion

##### 4.1 Inflow-performance relationship (IPR)

This section specifies the reservoir's inflow performance curve. When computing the IPR curve, the bottom-hole pressure and flow rate through the well are linked. In this case study, the "Darcy" model is used. As seen in the IPR curve below in Figure (9), the well (MB21) operate naturally at pressures of 4400 psia, respectively, with no water cut.

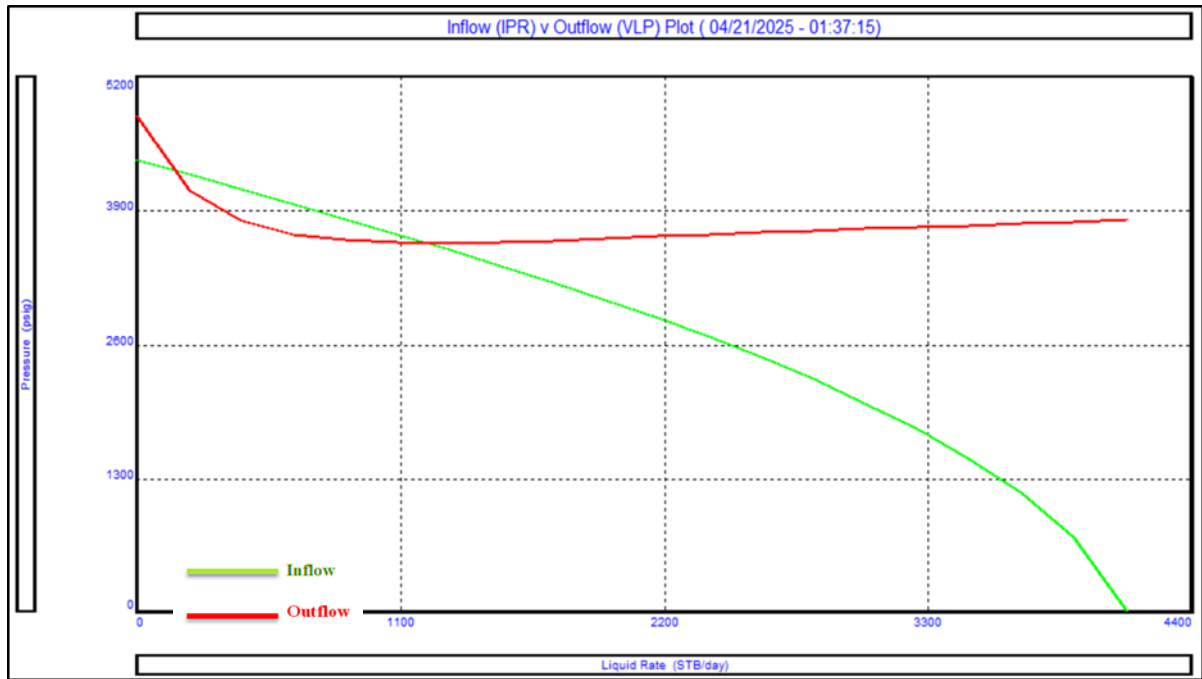


Figure 9: IPR & VLP Curves for Naturally Flowing Well (MB21)

#### 4.2 New Description of IPR

The water cut for the well (MB21) is lowered by about 25%, and the reservoir pressure dropped to 3000 psia Figure 10, resulting in the construction of a new IPR curve. To demonstrate how this would impact reservoir performance Figure 11.

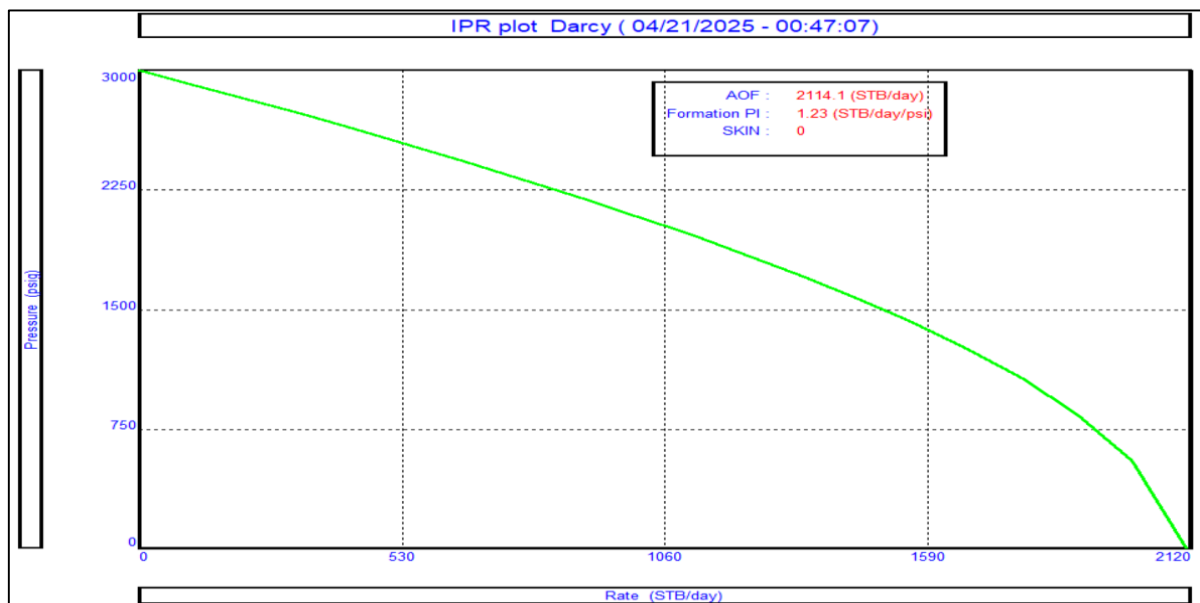


Figure 10: Inflow Performance Relationship for Well (MB21)

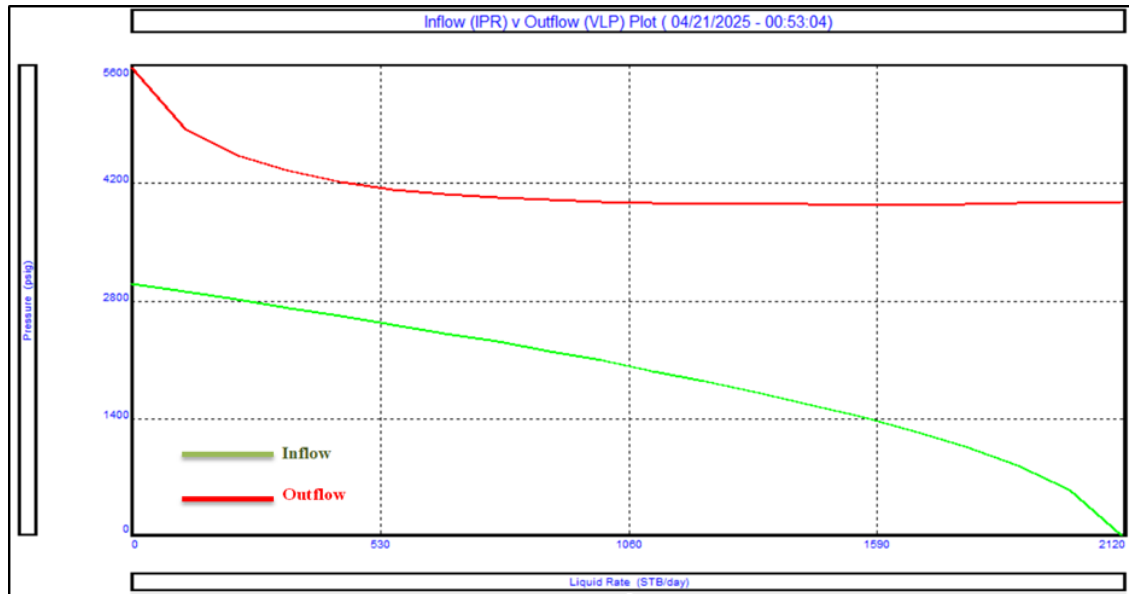


Figure 11: IPR and VLP Curves with 25% water cut without the use of Gas lift

### 4.3 Sensitivity Analysis

To maximize production, a PROSPER sensitivity analysis was carried out on the four main parameters water cut, injection depth, tubing diameter, and injected gas specific gravity that affect performance with gas lift. By adjusting these variables, the best gas lift design for maximizing production might be found. The best working conditions were identified by evaluating a variety of injection rates. The results of this methodical research can help operators design and operate gas lift systems for maximum well performance.

### 4.4 Injection Rate Effect

The quantity of gas available for injections influences the field's production performance. To boost overall field oil rate and gas-lift well performance, restricted gas injection must be distributed effectively. This section investigates how gas injection rates influence production flow rates in wells with gas lift flow. The goal is to determine how gas-lift technology may increase production rates.

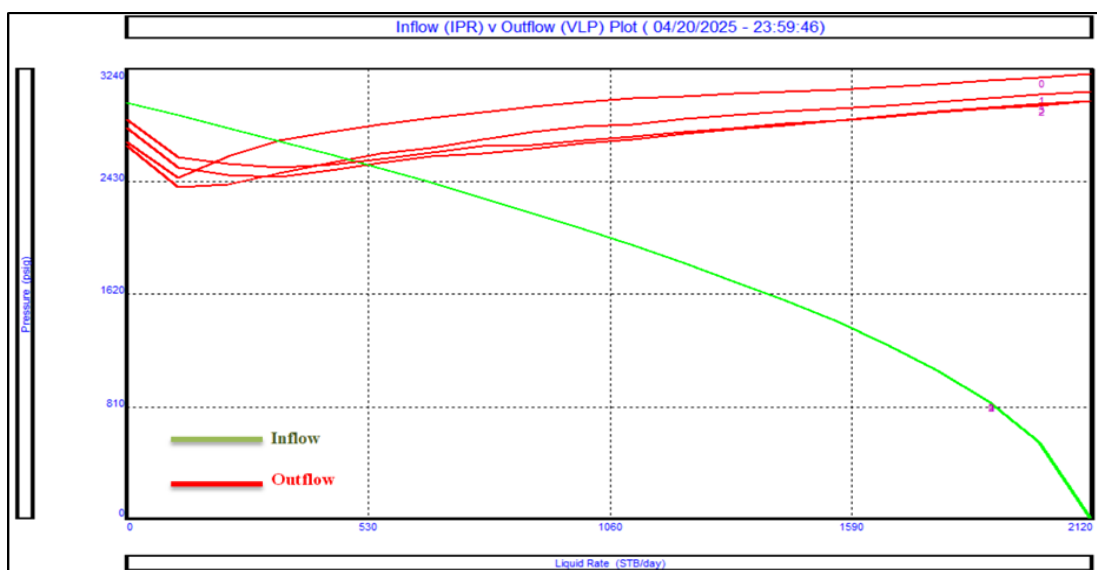


Figure 12: The Impact of Gas Injection Rates on IPR and VLP for Well (MB21)

The effect of different gas injection rates on oil production is depicted in Figure 12. Our first injection rate was 4 MMscf/day, which produced 363.6 stb/day of oil. Production increased to 396.6 stb/day when the injection rate was increased to 8 MMscf/day. However, oil production fell to 378.4 stb/day when we increased the rate even further to 10 MMscf/day. As seen in Figure 13 below, this suggests that even with an increase in injection rate, oil production fell, most likely because of restriction problems.

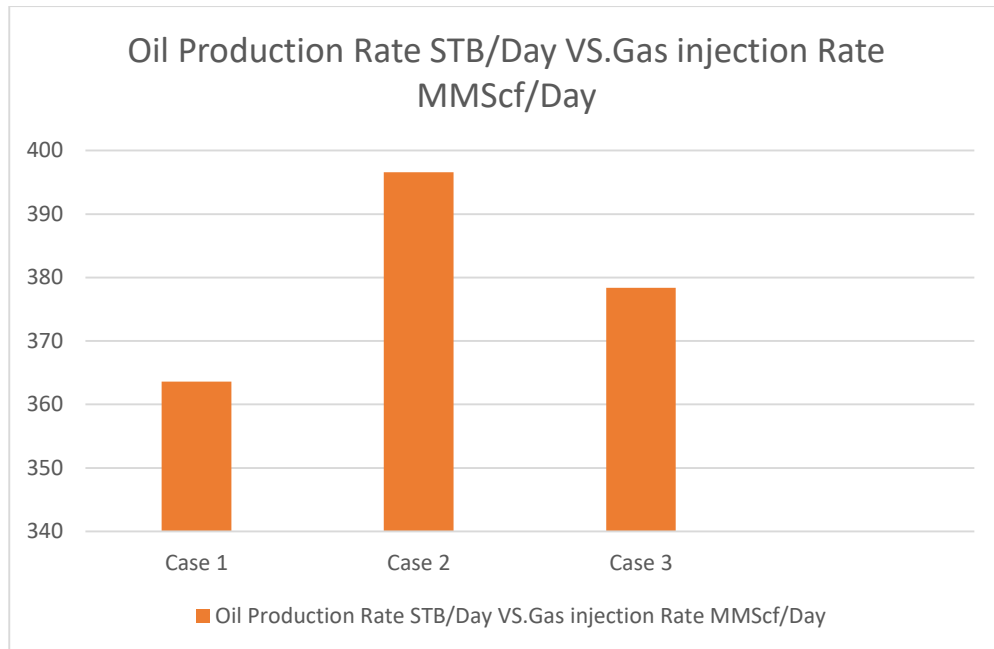


Figure 13: Results of the Gas Injection MMScf/Day on Oil Flow Rate STB/Day

#### 4.5 Effects of injected gas specific gravity

Gas specific gravity is one of the most important variables influencing the pace of oil production. We experimented with many circumstances to investigate this. By using a specific gravity of 0.65 sg at first, we were able to lower the oil production rate to 440.9 STB/day. We then raised the specific gravity to 0.70 sg, which caused the STB/day to drop even more to 410.8. Ultimately, the oil production rate dropped to 396.6 STB/day at a specific gravity of 0.75 sg Figure 14. Our results show that the oil production rate reduces with increasing gas specific gravity.

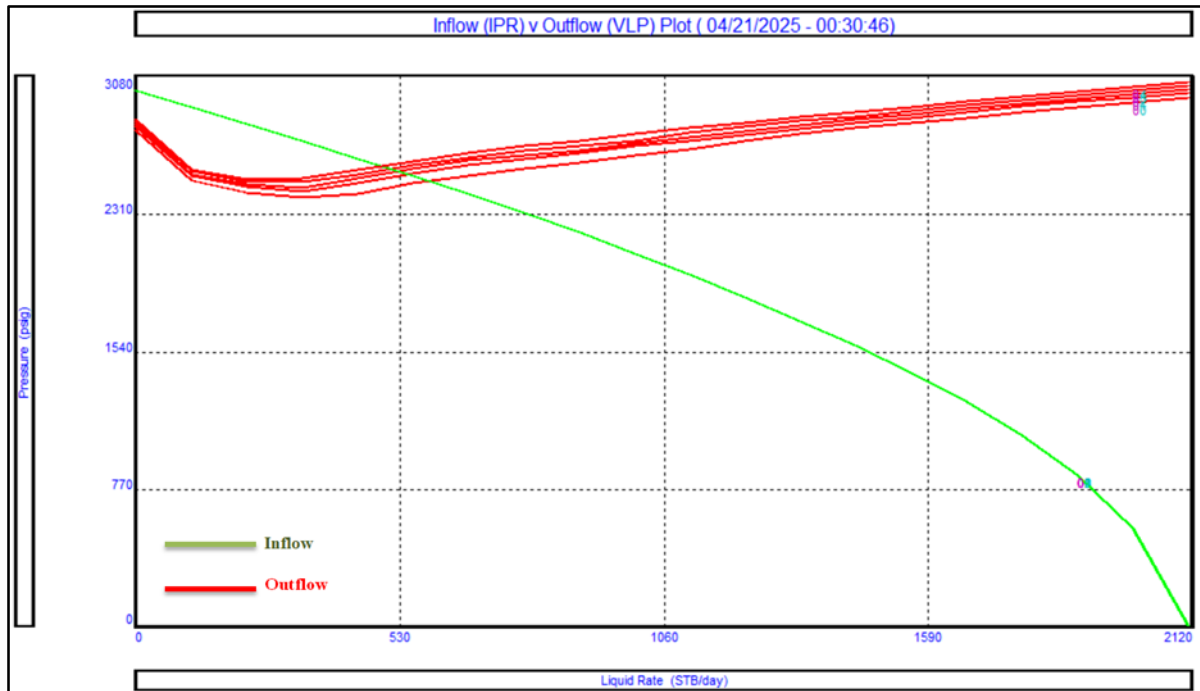


Figure 14: Nodal Analysis - Gas Specific Gravity (sp gravity)

#### 4.6 Effect of Water Cut

High water content is one of the main obstacles to oil field production since it causes drilling issues and lowers economic viability. Low reservoir pressure or high-water content might lower oil production and drawdown pressure as in Figure (15). Water production management is therefore required. The impact of water cut on well performance was assessed by experiments, which demonstrated that when water infiltration increases, interfacial tension rises and the liquid flow rate decreases.

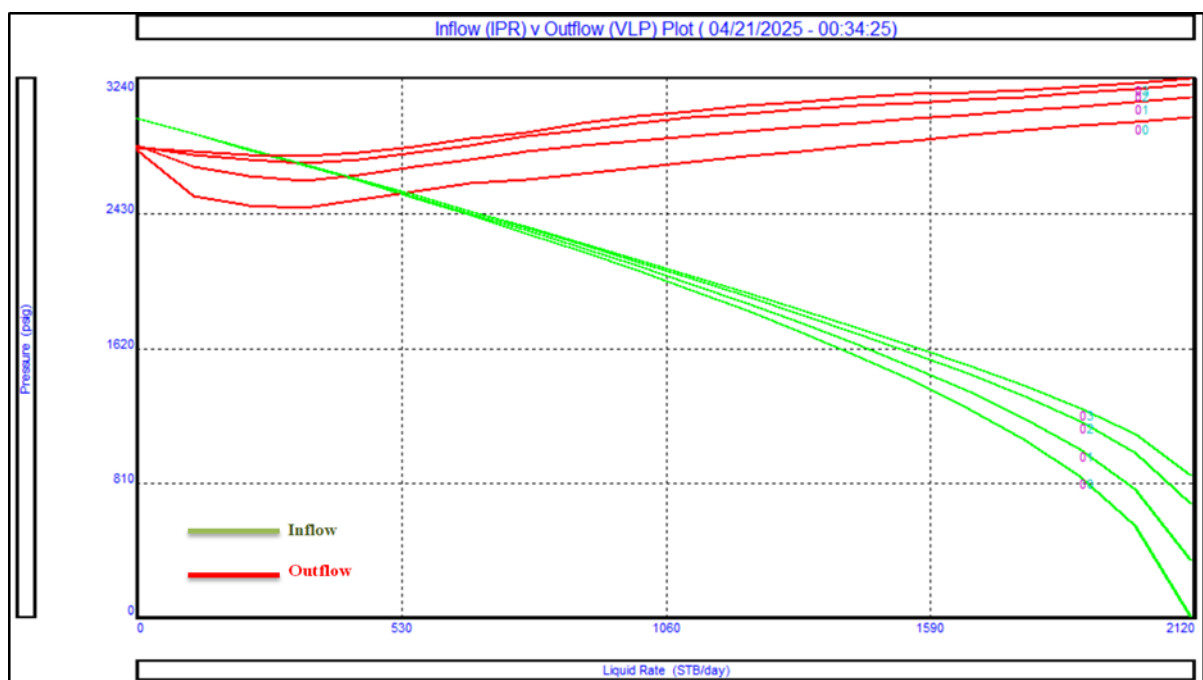


Figure 15: Nodal Analysis - Water Cut (%)

#### 4.7 Injection depth

Injection depth has a major effect on oil production rates. The oil production rate is 191.8 STB/day at a 6,500-foot injection depth. A production rate of 396.6 STB/day is obtained by increasing the depth to 7,500 feet, and it increases to 527.3 STB/day at 8,500 feet as in Figure (16). These findings demonstrate the link between higher oil production efficiency and deeper injection depths.

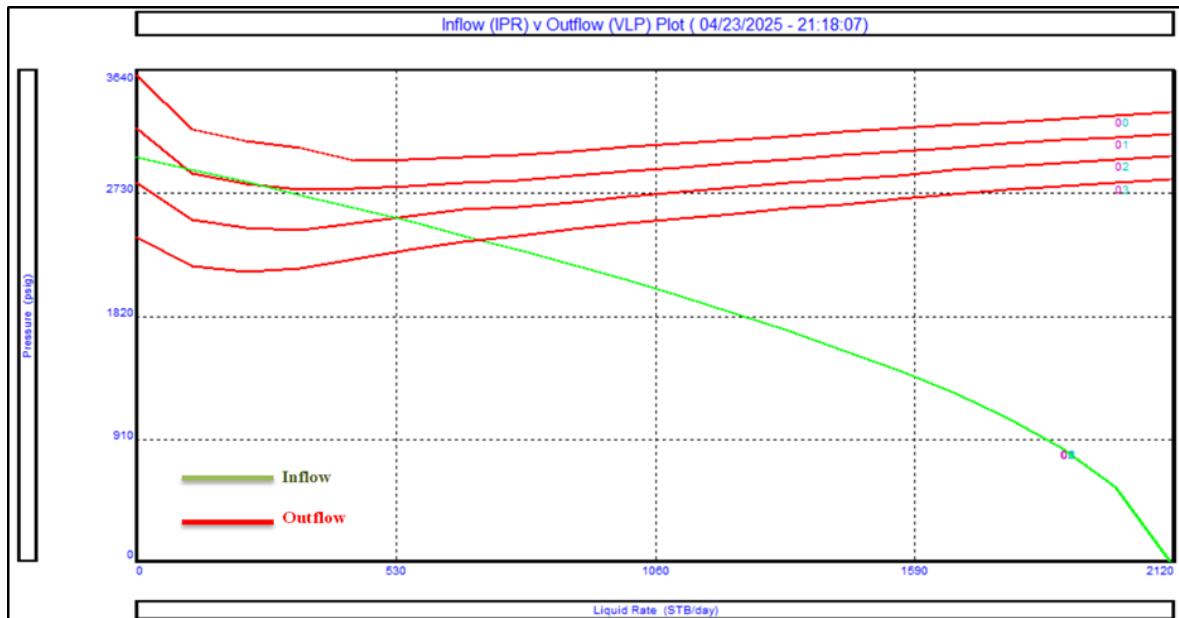


Figure 16: Nodal Analysis - Gas Injection Depth (ft)

#### 5. Conclusions

- The well (MB21) is initially producing 1029.3 STB/day with a 0% water cut.
- With a water cut of 25% and no gas lift technique, the well (MB21) produces zero oil.
- In Well MB21, gas lift was essential for resolving production issues brought on by the drop in reservoir pressure from 4400 psia to 3000 psia and increased water cut rates. From 0 MMscf/day to 363.6 MMscf/day, we greatly enhanced oil output by starting a gas injection rate of 4 MMscf/day. For comparable reservoirs at depletion pressure conditions, the efficacy and feasibility of gas lift are demonstrated by this successful gas injection optimization.
- The success of this study suggest that gas lift artificial lift could be applied to in other oil wells in Iraq that facing the similar issues. The findings of this research can be extended other fields in Iraq with similar conditions exist.
- When the injection rate was increased further to 10 MMscf/day, the oil production rate dropped to 378.4 MMscf/day due to system constraints.
- The well (MB21) may produce the most oil at a rate of 396.6 stb/day when the gas injection rate is optimized to 8 MMscf/day.

#### Conflict of Interests

The authors have declared no conflicts of interest.

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