Optimization of Gas Lift Performance. A Simulation Approach.

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Abstract: The most popular production technology in the world's oil and gas activities are artificial lift systems. Some wells need lifting help from the start; most everyone does at some point. To maximize the oil output from the oil wells, the Gas Lift System had to be optimized as part of this study's objective.

The primary job is to create an artificial gas lift system that aid production not under the currently operating conditions but also under unsuitable future circumstances in according to reservoir predicting, water cut is anticipated to rise by up to 50%, 60% and 70%. It is clearly discussed how to construct an optimal gas lift system using PROSPER.

According to the calculations, for the unloading procedure side pocket mandrels were fixed at certain depths. The remainder of the cases were then modified to fit the original side pocket mandrel spacing design, greater reservoir pressure and with lower water cut levels. The system was able to produce oil rates substantially over the minimum specified rates in every instance until the water cut level reaches 70% then well get loaded up and stopped producing. The anticipated output levels demonstrated that even poorer system productivity scenarios may be accommodated by the current completion schedule.

Keywords: *Artificial Lift, Gas Lift, Production Optimization*

1. Introduction

Oil wells in the early stages produce naturally to the surface but after some time as the reservoir pressure depletes, the hydrocarbons are unable to produce naturally. Artificial lift methods are employed to provide energy to lift oil from bottom of the hole to the surface in case oil is unable to reach surface or flow rate is not economical.

This method uses air or gas to be injected in the well to increase gas oil ratio. This makes pressure gradient to be declined from bottom to the surface. By decreasing pressure gradient bottom pressure is also reducing but pressure gradient of the reservoir is increased, this makes increment in the inflow. This phenomenon increases our oil production [1]. There are three stages of production of a well, viz primary, secondary, and tertiary. Primary production of a well is limited to natural flow of hydrocarbons to surface, and using an artificial device to support production, e.g., sucker rod pump, jet pump, ESP, gas lift accessory etc. Water flooding and gas flooding come into secondary production stage. Experiences have shown that primary and secondary can produce only 35% or less of original oil in place. Enhanced oil recovery is the final stage of production of a well. EOR methods change the fluid properties and makeup of the reservoir and produce the residual oil. EOR methods can increase production up to 75% of the original oil in place [2].

Gas artificial lift method is most important type of artificial method. It is required when the production is either not flowing or production is uneconomical. For this purpose, we inject prepared gas at the bottom of the well. [3]

Mainly in gas lift installed well, gas is injected between the annulus and the tubing. size of tubing is typically can be in the following range 2⅜, 2⅞, 3½, and 4 in. casing size smaller in diameter is 5½ in. in diameter. These configurations signify that we must neglect losses that take place due to friction. The gas that we inject will be having pressure at bottom equal to the pressure at the surface by gas and the hydrostatic pressure of the column of the gas. [4].

1.1. Classification of Gas Lift

1.1.1. Continuous Gas Lift Method

Gas is injected continuously at the bottom of the well. Injected gas reduces the density of the fluid that is unable to come up at the surface. By doing this hydrostatic pressure is reduced between the surface and the bottom. Therefore, fluid becomes able to easily rise to the surface.

1.1.2. Intermittent Gas Lift Method

In this type of gas lift method, gas is injected into the intervals to transport oil upward at surface by pressure of injected gas. After period of production well can build up its pressure later, again gas is injected. The injected gas has the capability to flush oil in the tubing upward. This process is repeated and again, and oil is produced in short intervals not continuously [3].

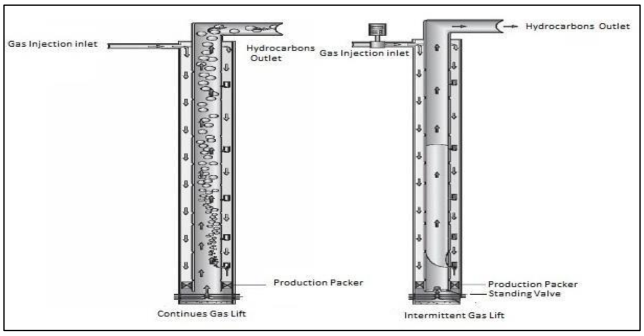

Fig: 1: Continuous and Intermittent Gas Lift Techniques[19]

2. Literature Review

Without natural driving forces (such as an aquifer or gas cap) or pressure maintenance mechanisms (such as water flooding or gas injection) to sustain reservoir energy, oil reservoirs will eventually be unable to produce fluids at economically viable rates. Around 50% of wells require artificial lift systems worldwide[14]. The majority of oil fields employ continuous gas lift system for producing oil at the surface because it is efficient, secure, and adaptable, leading to impressive oil production rates in both small and big diameter tubing[16]. This method uses air or gas to be injected in the well to increase gas oil ratio. This makes pressure gradient to be declined from bottom to the surface. By decreasing pressure gradient bottom pressure is also reducing but pressure gradient of the reservoir is increased, this makes increment in the inflow. This phenomenon increases our oil production[1]. Mainly in gas lift installed well, gas is injected between the annulus and the tubing. size of tubing is typically can be in the following range 2⅜, 2⅞, 3½, and 4 in. casing size smaller in diameter is 5½ in. in diameter. These configurations signify that we must neglect losses that take place due to friction. The gas that we inject will be having pressure at bottom equal to the pressure at the surface by gas and the hydrostatic pressure of the column of the gas[4]. Intermittent gas lift operations provide special control and management challenges in small closed rotative systems with limited gas storage capability in the low- and high-pressure lines[3]. Around 1900, the "law-lift" made it to the Texas-Louisiana Gulf Coast oil fields, where it started to be heavily utilized. Ten years later, California started using the technique, and shortly after that, gas rather than air started to be used as the lifting medium [15]. Additionally, the gas injection rate should be as inexpensive as possible[19].

3. Methodology

The selection of ALM is based on various factors, but listed below are the most important factors:

3.1. Consideration of depth

One simple method to include or exclude candidates is to use the graphs that show the limit of depth and speed at which different lift types may operate. These types of charts, together with benefit and disadvantage lists, are approximations of early selection options.

3.2. Net present value

The long-term financial viability of the available artificial lift technologies will determine a more detailed selection approach. The economics, in turn, are dependent on a number of variables that might differ from system to system, incorporating the percentage of system components that fail, fuel prices, maintenance expenses, inflation rates, and the projected earnings from the production of oil and gas.

NPV formula:

$$NPV = \sum_{i=1}^{n} \frac{WI(Q_{HC} \times P_{HC} - Cost - Tax)_i}{(1+k)^i} \quad \ldots\ldots\ldots\ldots(1)$$

3.3. Simulation of Model

PROSPER is a programme for analyzing the performance of production and systems. It helps the production or reservoir engineer forecast the temperature and hydraulics of tubing and pipelines accurately and quickly. The robust sensitivity calculation features of PROSPER make it possible to optimize an existing design. By giving them the tools to evaluate each producing well's performance critically, it enables petroleum companies to optimize their production earnings.

The PROSPER software has been used to create the well 15models used in this investigation. PROSPER creates distinct models for each part of the producing well system that affects overall performance and then enables performance comparison to validate each model subsystem. The programme makes sure the computation is as exact as it can be in this fashion. PROSPER is reliably used to model the well in various situations and can produce future forecasts of reservoir pressure using surface production data once the system model has been calibrated to real data.

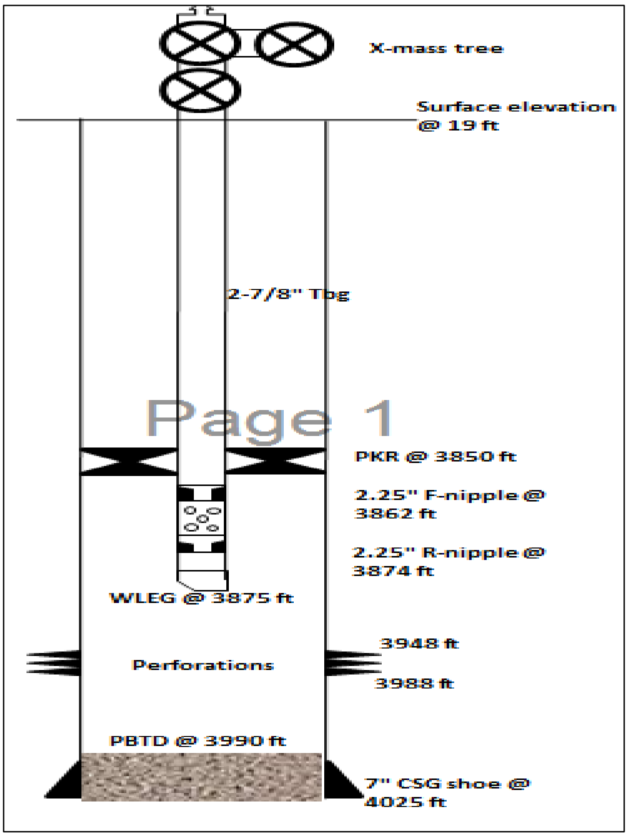

Fig: 2: Diagram of well

3.4. Input Data

Table.1. Well Data

Well Name	ABC-1
Field Name	ABC
Reservoir	XYZ
Well Type	Development
Country	Pakistan
Primary Target	Lockhart formation
Total Depth	4025 ft
Well Status	Oil Well

Table.2. Gas lift Input Data

Parameters	Values	Unit
Gas Lift's gas gravity	0.7	
H2s, CO2 & N2	0	%
Gas liquid ratio (GLR) Injected	1500	scf/stb
Injected Gas gravity	0.6	
Max depth of injection	3500	Ft
Casing pressure	1000	Psi
dp across valve	100	Psi
Total GOR	428	scf/stb
Gas rate available	1.5	MMscfd
FWHP during Gas lift	200	Psi
Water cut	90	%
Free GOR	250	scf/stb
Gauge depth	3950	Ft
Gauge pressure (FBHP)	1020	Psi

Table.3. Reservoir Data

Parameters	Values	Unit
Reservoir Pressure (Initial & Pb)	1738	Psi
Reservoir pressure (current)	1113	Psi
Reservoir Temperature	175	deg F
Water cut	81.64	%
Productivity Index	25	Bbl/d/psi

Table.4. PVT Data

Parameters	Values	Unit
Solution Gas Oil Ratio (GOR)	300	scf/stb
Oil Gravity	44	API
GOR	428	scf/stb
Gas gravity	0.749	
Oil FVF	1.285	bbl/stb
Water salinity	120000	Ppm
H_2S	0	%
CO_2	1.38	%
N_2	26.36	%
Producing GOR	1905	scf/stb

Table.5. Reservoir Characteristics

Parameters	Values	Units
Reservoir Permeability	50	md
Reservoir Thickness	100	feet
Drainage Area	500	acres
Dietz Shape Factor	31.6	
Wellbore Radius	0.75	meter

Table.6. Wellbore Data

Parameters	Values	Unit
Vertical well	-	-
Mid perforations depth	3968	Ft
2-7/8" tubing, 6.2 ppf (ID=2.441")	3875	Ft
2.25" F-nipple (ID=2.25")	3862	Ft
2.25" R-nipple (ID=2.19")	3874	Ft
Temperature at surface (19 ft)	80	deg F
Overall heat coefficient	8	BTU/h/ft^2/°F

Table.7. Well Test Data

Parameters	Values	Unit
Test type	Pressure build-up	-
Reservoir Pressure	1113	Psi
FWHP	150	Psi
FWHT	150	deg F
Liquid rate	2500	Blpd
Water cut	50	%
GOR	500	scf/stb

4. Results and Discussion

4.1. Initial Conditions

The graph below (Fig: 3) includes the PROSPER Model generated plot first for the data given which involves the rates oil production and Pressure, this graph shows that the well was not flowing as the needed force to move hydrocarbons to the top was not enough to push the fluid to the surface from the wellbore. As the reservoir was producing and had enough energy to push the fluid towards the wellbore but that was not enough to take the fluid to the surface. In this case an artificial system that can lift the fluid is preferably installed to make fluid flow to the surface.

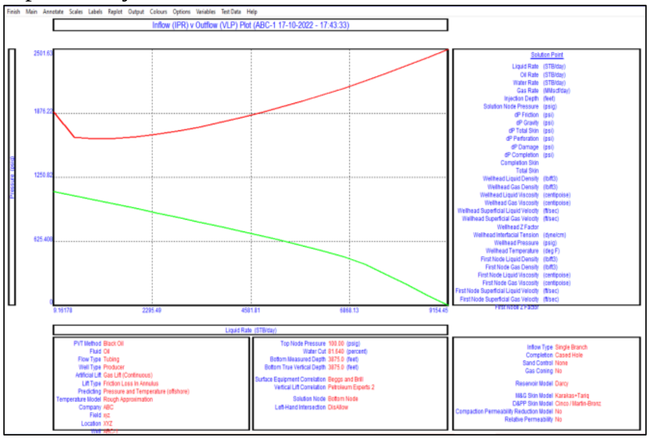

Fig: 3: Inflow vs Vertical performance curves prior to any gas injection

Below curve (Fig. 4 and 5) shows the relation between drawdown pressure and oil flow rate. It depicts that pressure has inverse relation with flow rate as drawdown pressure is increasing oil flow rate is increasing. Straight curve is generated but after achieving bubble point pressure it deviates from straight line behavior. Absolute open flow (AOF) is 19600stb/day for this well. This rate is not achievable because bottom hole flowing pressure cannot go down to zero in practical cases.

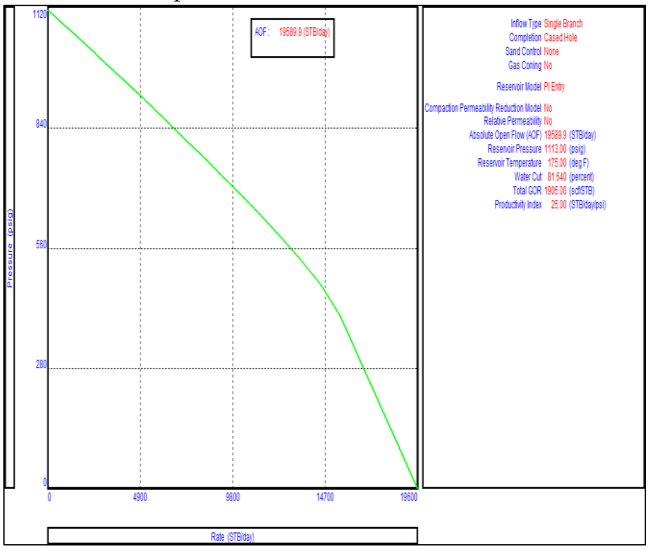

Fig: 4: IPR PLOT

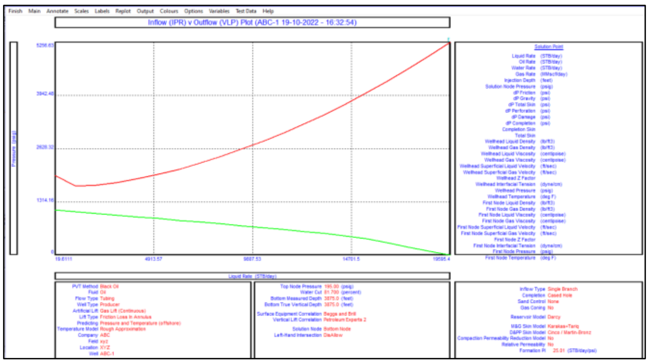

Fig: 5: IPR vs VLP curves of the well without any gas injection

We here see that well is producing at GOR of 750 and 50% WC and 60% WC. But sensitivity analysis depicts that well loads up before reaching 70% WC. The well at this condition is in the situation when natural reservoir energy is unable to lift hydrocarbons up the surface because liquid column hydrostatic pressure in the tubing is greater than reservoir pressure. Due to high density of water well cannot be produced until liquid column in the tubing is removed. The process of removing kill liquid in the tubing so that well can be put back on production again is called unloading. The unloading will lower hydrostatic pressure in the tubing and increase bottom hole flowing pressure and put well back on production. Gas lift method would be used to unload the well and decrease hydrostatic pressure in the tubing continuously to produce oil well at higher rate.

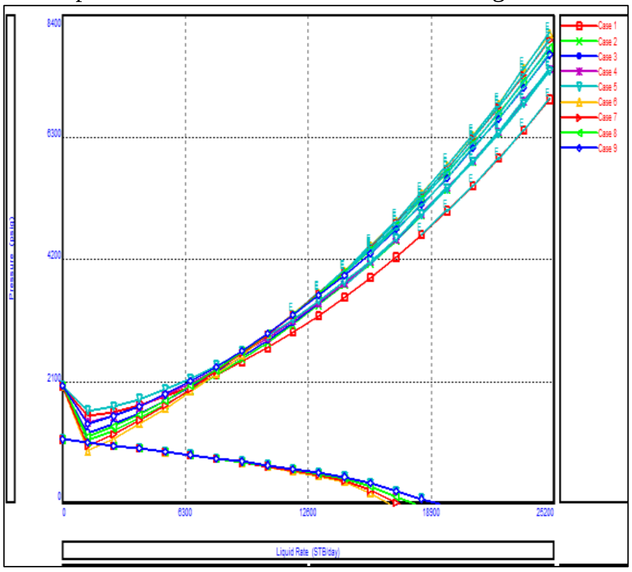

Fig: 6: Inflow (IPR) Vs Outflow (VLP) Plot of All Cases

This figure 7 shows that at the water cut of 50 percent and gas oil ratio of 750scf/d, the well is still in the producing condition.

Solution

Solution Details		
Liquid Rate	2094.0	STB/day
Gas Rate	0.78527	MMscf/day
Oil Rate	1047.0	STB/day
Water Rate	1047.0	STB/day
Solution Node Pressure	1027.57	psig
Wellhead Pressure	200.00	psig
Wellhead Temperature	142.40	deg F
First Node Temperature	142.40	deg F
Total Skin	0	
Total dP Skin	0	psi
dP Friction	122.56	psi
dP Gravity	696.01	psi

Fig: 7: Case 06 Data

This figure 8 shows that at the water cut of 60 percent and gas oil ratio of 750scf/d, the well is still in the producing condition. But the oil rate has been decreased.

Solution

Solution Details		
Liquid Rate	1600.0	STB/day
Gas Rate	0.48	MMscf/day
Oil Rate	640.0	STB/day
Water Rate	960.0	STB/day
Solution Node Pressure	1048.22	psig
Wellhead Pressure	200.00	psig
Wellhead Temperature	137.93	deg F
First Node Temperature	137.93	deg F
Total Skin	0	
Total dP Skin	0	psi
dP Friction	71.84	psi
dP Gravity	769.06	psi

Fig: 8: Case 07 Data

This figure 9 shows that at the water cut of 70 percent and gas oil ratio of 750scf/d, the well has been loaded up due to the hydrostatic pressure that has been increased and the production has ceased.

Solution

Solution Details		
Liquid Rate		STB/day
Gas Rate		MMscf/day
Oil Rate		STB/day
Water Rate		STB/day
Solution Node Pressure		psig
Wellhead Pressure		psig
Wellhead Temperature		deg F
First Node Temperature		deg F
Total Skin		
Total dP Skin		psi
dP Friction		psi
dP Gravity		psi

Fig: 9: Case 8 Data

4.2. Gas Lift Modelling

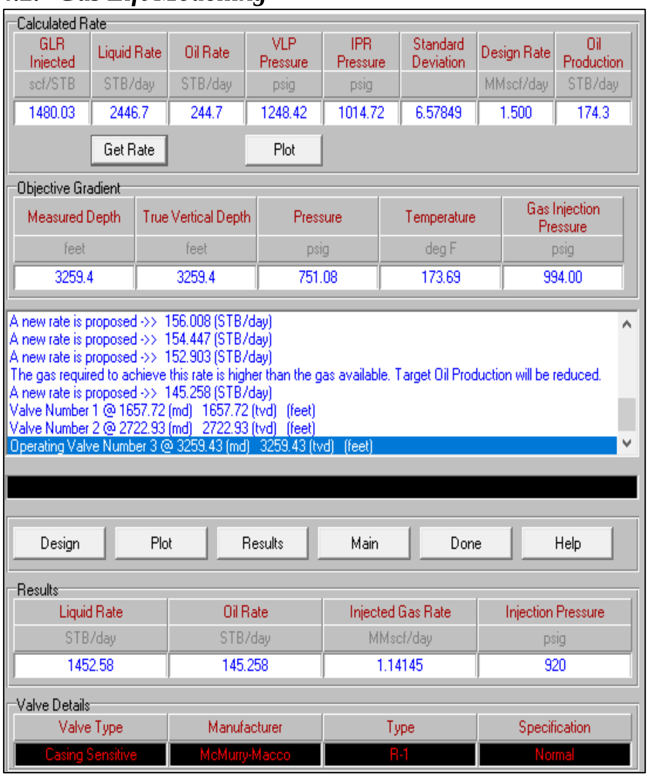

Fig: 10: Gas lift design-calculated rate

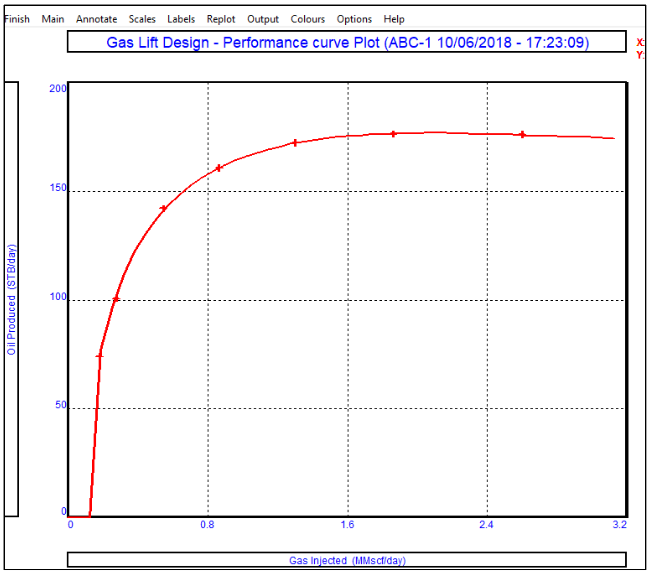

Fig: 11: Production rate vs Gas injection rate

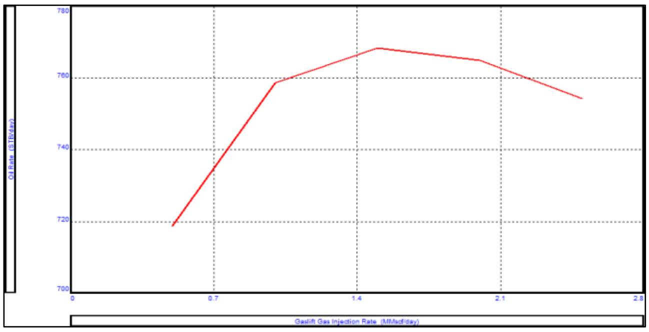

Fig: 12: Oil rate vs Gas injection rate

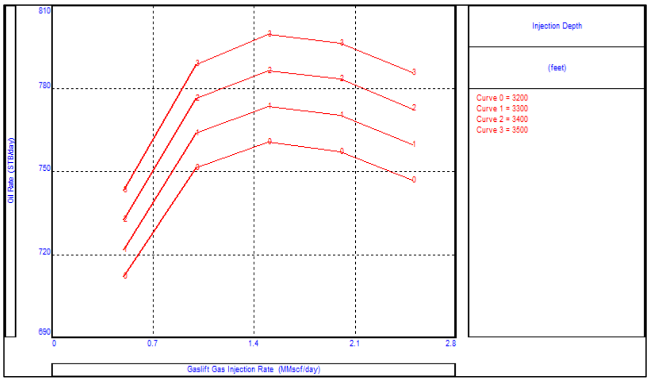

Fig: 13: Oil rate vs Depth

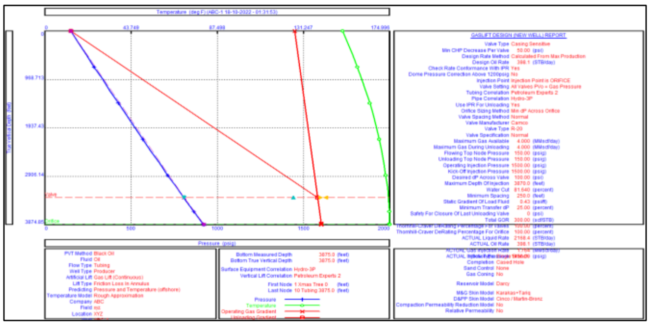
Fig: 14: Artificial Gas Lift Design Pressure v Depth Plot

5. Conclusions

Before implementing gas lift method, well was loaded up and production rate was zero. Therefore, well needed some sort of artificial lift method to get well unloaded and put it back to production. These wells are modelled using the PROSPER tool, which requires the entry of raw field data on the characteristics of the reservoir fluids as well as data from well testing for PVT matching and producing IPR and VLP for the well. In PROSPER, the well is incrementally simulated, and data is input more carefully. However, correlation comparison and Petroleum Expert-2 are used to produce the VLP and IPR curves. Based on the source supply that is accessible and taking bubble point pressure into account, design injection pressure is input.

The gas injection rate sensitivity results have shown that optimum oil rate is achieved as 767 bbl/day at the gas injection rate of 1.575MMscf/day. This is the final optimum point for gas injection rate above which only gas will be produced more and will adversely affect the oil rate.

According to the findings of the sensitivity depth injection, a gas lift injection rate of 1.6MMscf/day leads in a maximum oil production rate of 800 bbl/day at a gas injection depth of 3500 ft. Finally, 3500 feet is determined to be the ideal injection depth for the well's fixed gas injection rate in MMscf/day. Therefore, it can be stated that the deepest injection point is the ideal depth at which we can get the highest production rate.

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