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Using the Artificial Gas Lift to Increase the Productivity of Noor Oil Field / Mishrif Formation

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Abstract

Noor Oil Field is one of Iraqi oil fields located in Missan province / Amarah city. This field is not subjected to licensing rounds, but depends on the national effort of Missan Oil Company. The first two wells in the field were drilled in seventies and were not opened to production until 2009. The aim of this study is to study the possibility of using the method of gas lift to increase the productivity of this field . PROSPER software was used to design the continuous gas lift by using maximum production rate in the design.

The design was made after comparing the measured pressure with the calculated pressure, this comparison show that the method of Beggs-Brill and Petroleum Expert2 gave the best results; therefore, these correlations have been adopted in the design of gas lift.

The point of gas injection had been selected; the optimum gas injection rate, the maximum oil production rate, the number of valves required for gas injection and their depth, the pressure required to open and close each valve were calculated. The effect of water-cut, change the amount of ratio of gas to oil and decline reservoir pressure in natural flow case and gas lift method case were studied. The results of gas lift design show that the maximum oil production rate is (1000) STB/Day and the optimum gas injection rate (2.65) MM Scf/Day at using operating pressure of (1700) psi available at casing head and the minimum bottom hole following pressure is (1501.5) psi.

Key Words: Artificial gas, Noor oil field

Introduction

When oil is first exist in the reservoir, it is under pressure from the natural forces that surround and trap it. If a well is drilled into the reservoir, an opening is provided at a much lower pressure through which the fluid can escape. The driving force which causes the fluid to move out of the reservoir and into the wellbore comes from the compression of the fluids that are stored in the reservoir. The actual energy that causes a well to produce oil results from a reduction in pressure between the reservoir and the producing facility on the surface [1]. If the pressures in the wellbore and the reservoir are allowed to equalize, either because of a decrease in reservoir pressure or an increase in wellbore and surface pressure, there will be no flow from the reservoir and hence no production from the well.[2]

There are a number of factors that affect the producing characteristics of an oil well. These factors are often interrelated and may include such things as fluid properties of the oil itself, amount of gas and water associated with the oil, properties of the reservoir, size of the producing pipe and related subsurface equipment. Also the size and length of the flow line connecting the well to the production facilities are consider from factor that affect the producing characteristics . All of these factors play an important part in an oil well’s performance and most carefully considered when the installation is designed. [1] An ideal production installation makes maximum use of the natural energy available from the reservoir.

In many wells the natural energy associated with the oil will not produce sufficient pressure differential between the reservoir and the wellbore to cause the well to flow into the production facilities at the surface. [1]

There are basically four ways of producing an oil well by artificial lift. These are: gas lift, sucker rod pumping, electrical submersible pumping and subsurface hydraulic pumping. [3]

The choice of the artificial lift system in a given well depends on some factors, primary among them, as far as gas lift is concerned, is the availability of lift gas, either as dissolved gas in the produced oil, or from an outside source, then gas lift is often an ideal selection for artificial lift. Gas lift is the method of artificial lift that most closely resembles the natural flow process. There are basically two types of gas lift systems used in the oil industry, they are: continuous flow and intermittent flow.

Brief Idea about Noor Field

Noor oil field is located in the south of Iraq in Missan governorate and about 4 kms west Iranian border, 25 Kms north Halfaya field, 20 Kms east of Buzurgan field, 17 Kms east of Amara field.[4] Noor structure is a gentle closed anticline fold extending north west-south east. The field is about 18 to 20 km in long and 5.5 to 7.5 km in width. The main reservoirs in the field are "Mishrif" and "Nahr Umer" formation. The crude oil of "Mishrif" formation has a gravity of about (23) API, this relatively low API gravity makes the natural of oil up the production string at some desired rate impractical. The formation is composed of limestone rocks with little shale.

The total thickness of the formation is about (385 m) and it is divided in to four major units and four barriers depending on information obtain from Ministry of Oil. Total number of wells were drilled in the field are 11 wells, eight wells are completed in Mishrif reservoir and the rest are completed in Nahr Umer reservoir.

The first well in the field (Noor-1) was drilled on 2 July 1977 and completed on 22 February 1978, it reached a maximum depth of 4938m. The last wells in the field (Noor-9), (Noor-10) and (Noor-12) had been drilled in 2013, but these wells were not put on stream up to now. The actual production from the field was started from two wells at February 2009 and reached to eight production wells.

Literature Review

Historical Development of Gas Allocation:

Mayhill [5] analyzed the relationship between the gas injection rate and the oil production rate, and called the curve a " gas lift lance curve". He defined the most efficient gas injection rate as rate at which an incremental expense for gas injection is equal to percentage of the incremental revenue produced at that gas injection. Radden et al. [6] presented an analytical procedure to line the most profitable distribution of gas to wells in a continuous gas lift system. They developed a computer program to perform calculations for the gas allocation and it was successfully applied to a Venezuela field for a group of thirty wells. Gomez[7] proposed a procedure to generate the gas lift performance curve and also developed a computer program which fitted second degree polynomial to each gas lift performance curve by the least square method. This polynomial was then used to determine which would produce the largest amount of oil when equal amounts of incremental gas were injected into each well.

This well would then be allocated this incremental amount of gas, and this procedure would be continued until all the available injection gas volume is used. Hong [8] investigated the effects of several variables on continuous flow gas lift systems. He used a system consisting of six gas wells and surface flow lines, and optimized the system under the condition of variable well head pressures. The procedure for finding the optimum gas injection rate is basically the same as that proposed by Gomez.

However Hong employed a cubic spline interpolation technique for the estimation of the gas lift performance curves. Kanu et.al [9] established the method of equal slope allocation method under both unlimited and limited gas supplies. They presented the formulation of the economic slope and the use of this slope to allocate a total amount of gas at the optimal economic point for a group of wells in a step by step procedure. Nishikiori et.al. [10] developed a new method for finding the optimum gas injection rate for a group of continuous gas-lift wells to maximize the total oil production rate. The new method was a quasi-Newton non-linear optimization technique, which is incorporated with the gradient projection method. A computer program is developed capable of implementing the new optimization method as well as generating the initial estimate of the gas injection rates.

Theoretical Background

Vogel [11] developed an empirical technique for predicting well productivity's under such reduced condition and he called his method of analysis Inflow Performance Relationship (IPR) and then used for wells producing from several fictitious solution gas drive reservoir from these curves he was able to develop a reference IPR curve which not only could be used for most solution gas drive reservoirs .However, good experience has been obtained using the Vogel IPR in all two- phase flow conditions. The Vogel IPR dimensionless curve is based on the following equation:

$$\frac{Q_o}{(Q_o)_{\max}} = 1.0 - 0.2\left(\frac{P_{wf}}{P_R}\right) - 0.8\left(\frac{P_{wf}}{P_R}\right)^2 \quad \text{... (1)}$$

The initial bubble point pressure (Pb) can be substituted instead of the average reservoir pressure (PR) in the above equation to emphasize that the Vogel IPR curve would be applied when PR > Pb.

Flow Regimes

Flow pattern or regimes frequently encountered in vertical two – phase flow are shown in figures (1) & (2). Most investigators who consider flow regimes define four regimes which may occur in a vertical pipe. Although different names are given these regimes, most of the methods discussed in this section use essentially the same description for these four flow regimes[12].

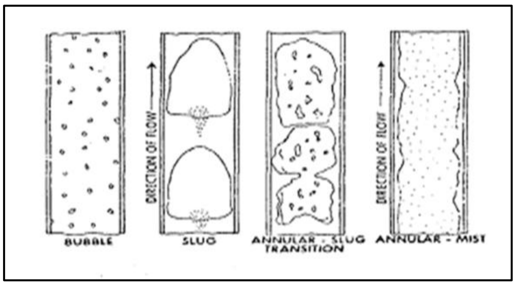

Fig. 1, Vertical flow patterns

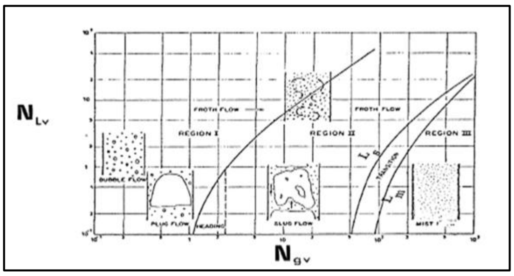

Fig. 2, Flow regime map

Modified Beggs and Brill Method

For single phase can be modified for multi-phase flow by considering the fluids to be homogeneous mixture[13]. Thus:

$$\frac{dp}{dL}=\frac{f\rho v^2}{2d}+\rho g\sin\theta+\rho v\frac{dv}{dL} \qquad \dots (2)$$

Where the definition for ρ and v can vary with different investigators.

Equation (2) shows that the total pressure drop for a two phase flow pipeline is the sum of the pressure losses due to:

1- Fluid friction effects,
2- Hydrostatic head effects, and
3- Kinetic energy or acceleration effects.

Thus:

$$\Delta Pt = \Delta P\ f + \Delta P\ E + \Delta P\ KE \qquad \dots(3)$$

Gas Lift Performance

The (PROSPER) software, Production and System Performance, presented by Petroleum Experts Limited's had been adopted to match the real data and predict tubing and pipeline hydraulics. Because the lack of sufficient information of Mishrif Reservoir/ Noor Oil Field, well Noor-2 was chosen for application artificial gas lift and is regarded as the rest of the wells in the field which need to apply the gas lift. [14]

Match the PVT to Real Data:

Black oil method had been used to determine the P.V.T properties and the main laboratory- measured fluid properties that loaded into PROSPER software and used to get PVT match which were listed in table (1).

Table (1): Data Used to Match PVT Properties [14]

Property	Value
Solution gas oil ratio (Scf/Day)	620
Gas gravity	0.76
Water Salinity (ppm)	180000
Reservoir pressure (psi)	5306.66
Bubble point pressure (Psi)	2626
Oil F.V.F (RBBL/STB)	1.4246 @ pb
Oil viscosity (cp)	0.9 @ pb
Temperature	103 C°

The correlations that match PVT properties were Glaso correlation for bubble point (Pb), gas oil ratio in solutions (RS) and formation volume (Bo), Beal et al correlation for oil viscosity property.

The Inflow Performance (IPR):

By using Vogel's equation to calculate PI value and the initial reservoir pressure which obtained from the well Noor-2 test as input data in the software. These input data used to plotted IPR were: reservoir pressure was 5306.66 psi, PI equal to 1.88 (STB/Day/ psi) and 0 % water-cut. Figure (3) shows the IPR plot.

Pressure Gradient Match:

When well head pressure and top of perforation depth have been available then Pressure Gradient can be plotted by PROSPER software. Many correlation methods were used to make sure that they match the pressure gradient.

As shown in figure (4) and (5), Beggs-Brill and Petroleum Experts-2 methods have a good gradient match. Data that used to obtain the gradient match were: Well head pressure 675 psi and top of perforation 3366 m.

Outflow Performance (VLP):

Depending on pressure gradient match, Beggs- Brill and Petroleum Experts-2 methods were the best correlation method which used to represent VLP (Vertical Lift Performance). As shown in figures (6) and (7), the intersection point between IPR and VLP represent the flowing bottom hole pressure and flow rate of the total system.

Gas Lift Design

Gas Lift Design –Performance Curve Plot:

According to design conditions; the maximum oil rate of well Noor-2 could produce was 1000 STB/Day with 2.65 MM SCF/Day of gas injected at optimum depth of injection, the maximum oil production shown in figure (8).

Gas Lift Design-The Position of the Operating and Unloading Valves:

Figure (9) display the position of the operating and unloading valves at final design condition and the plot of tubing and casing pressure gradients for the design rate.

Results and Discussion

To prove the efficiency of gas lift in the current research, a comparison made between natural flow and flow with gas lift for different water-cut 10%, 20%, 30 %, 40%, 50%, the calculations was carried out at surface operating pressure of 1700 psi for gas lift process. For example the case where the results show that the well Noor-2 continue to produce when water-cut raise to 50%, reservoir pressure 5300 psi and the first node pressure 675 psi if gas lift process has been applied while this well cannot produce naturally at the same conditions, this case shown in figure (10).

The main conclusions of the current study can be summarized as following:

1- Prosper software had been used to predict the vertical pressure-losses correlations as depending on the test of well Noor-2, this software showed that the best correlations for Noor wells are modified Beggs – Brill and Petroleum Expert 2.
2- The correlations Glaso correlation for bubble point (Pb), gas oil ratio in solutions (RS) and formation volume (Bo) also Beal et al correlation for oil viscosity property gave a good matching.
3- Get an acceptable differences percent at the intersection point during VLP/IPR matching.
4- The results have shown that the optimum gas injection rate equal to (2.65MSCF/BBL) for well Noor-2.
5- The maximum oil production rate that can obtained from gas lift design is 1000(STB/Day).
6- The surface operating pressure, as Pso had role to make the point of injection as deep as possible and to be able to injection the required amount of gas.
7- The numbers and locations of gas lift valves are depending on operating gas injection pressure.

Nomenclature

Q_o Oil Flow Rate, bbl/ day.
$Q_{o\ max}$ Maximum Oil flow Rate , bbl/ day.
P_{wf} Flowing Bottom Hole Pressure, psi.
P_R Reservoir Pressure, psi.
$\Delta P\ t$ total pressure drop, psi.
$\Delta P\ f$ pressure drop due to friction, psi.
$\Delta P\ E$ pressure drop due to elevation, psi.
$\Delta P\ KE$ pressure drop due to kinetic

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