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Prediction of Water Injection Time for an Iraqi Oilfield to Sustain the Natural Flow through Using PROSPER-IPM Software

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Abstract

This paper launch a brief on the effect of production in an oilfield in Iraq on the natural production through pressure depletion, and amount of psi pressure lost per month and hence per year. The science of production engineering, one of the important tasks to monitor is the change in the reservoir pressure which is the source of all pressure within a well production system. Nowadays, petroleum Softwares are valid for matching the test and measurement data to establish an intensive prediction for future probabilities. This work is done as key entry point for future plan and requirements in one of the oilfield in Iraq under the current production rate. The name of the field is considered as FK-OILFIELD due to the confidentiality of data. The oil production mainly has been produced from the K field for about 6 years starting with around 10,000 bbl/day for the first year and gradually increasing to 120,000 bbl/day now. The production data are in cooperated with bottom-hole field measurement data via PROSPER Software which is mainly focuses on production test parameters Pressure and Flow Rate. This paper contains a brief introduction to the one of the tasks of petroleum production engineers and then how production naturally occurs within the oil wells production systems. Additionally, outcomes of field measurements and production data history are used for modelling the reservoir and wellbore performance of the field. One well is selected around the field for modeling the PROSPER Simulation and sensitivities are carried out considering the field bottom-hole data, especially pressure history. The well is named as FK-OILFIELD Well.

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The outcomes of the simulation and data history are considered for predicting of losing natural flow in the field through depletion and reservoir pressure sensitivity are tried for that purpose.

Keywords: PROSPER Software; OILFIELD; Bottom-hole data; Pressure and Flow Rate.

1. Introduction

1.1. Background

Nowadays IPM Software packages are reliable for monitoring reservoir performances, where System requirements of data inputting is followed according to the model construction. This will result in a complete production system for matching well test data (measured) with modelled data (calculated), consequently obtaining operating condition for the selected well showing the capacity of the wells within the studied field. The purpose of field measurement data recording unit (SLICKLINE) is to monitor the fluids levels and reservoir pressure and temperature of the subsurface of the field. Furthermore, keeping the observation on bottom hole pressure monitoring at a rate that is enough to collect data for better portray the driving force in the reservoir. Three different wells have been selected for conducting this study taking their location in the field into consideration; first, a well at the south of the field. Second, a well at the middle part of the field and finally a well at the north part.

1.2. Objective

The objectives of this paper are:

A. Constructing a PROSPER Modell for the nominated wells.
B. Sensitivities analysis on naturally production from the field through considering Field Measured Bottom-Hole data.
C. Predicting a time for starting water injection to support reservoir pressure.

1.3. Field Overview

The K field is about 22 km long and 3 km wide. Hydrocarbons are produced from the Tertiary (main limestone) reservoir, a fold hydrocarbon trap (Anticline fold) and rock type is Dolomitic limestone with reasonably good porosity and permeability, which is characterized by natural fractures. The oil column thickness is thought to be about 60 - 90 m sandwiched between a large gas cap and aquifer. The production has started from the field mainly in 2009 up to now where at the beginning reservoir pressure recorded in three parts of the field; north, middle and south as high, medium and low respectively [14].

1.4. Natural Flow

The causes of the trapped fluid within any reservoir to flow up to the surface are controlled by the reservoir pressure. Normally, when the petroleum is formed and accumulated in the traps energy will be stored and makes reservoir fluids to flow from the porous of rocks into the wellbore. The main two pressure differences which are controlling the naturally flowing oil reservoir fluids are pressure drop within the reservoir (drawdown pressure) and pressure drop within the wellbore (draw up) [15].

In all production systems and at each component there will be restrictions towards the flow of the fluids. The points that cause the pressure drop, hence natural flow occurs'

- At the sand phase or gravel pack or perforation section.
- At the vertical system ($P\_hydrostatic$+ friction force)
- At the surface facilities (chokes, flow lines, separators)

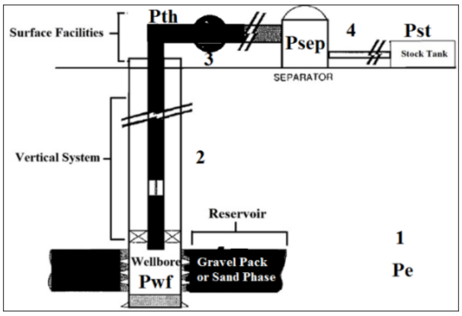


Figure 1: Typical Production System with Pressure Components Parameters [4]

2. Problem Statement

Oil wells under the initial condition when having under-saturated oil reservoirs (PR > Pb) are flowing naturally through pressure depletion across production system restrictions. For example, the difference between the reservoir pressure and bottom-hole pressure, the one between bottom-hole flowing pressure and wellhead pressure and between wellhead flowing pressure and separator pressure. When started with production the cause of all pressures (Reservoir Pressure) declines according to the productivity index equation ($PI = J = \frac{Q_o}{P_R - P_{wf}}$)in bbl/day/psi. i.e. producing oil with higher PI, more psi will be lost from the reservoir. Figure 2 illustrates the reasons why it is required to indicate a definite time for secondary recovery methods to reinforce the loosen pressure from the reservoir. Through looking at this figure, wells normally can produce by their own reservoir pressure only for a specific period of time.

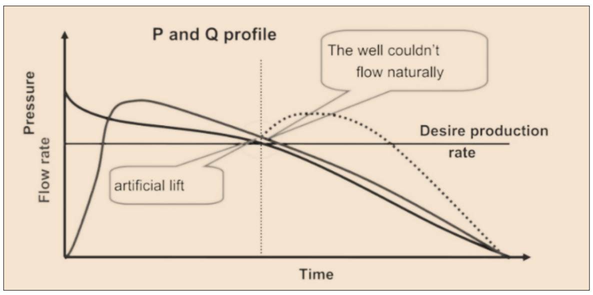


Figure 2: pressure versus Flow Rate Profile [2]

With more pressure decline from the reservoir, the desired rate will decline, hence a project should be planned for sustaining the natural flow. Therefore, the owner of the oilfields usually is recommended to optimize the production through one of the methods of secondary recovery, for instance; water injection [2].

3. FK-oilfield reservoir pressure history

Using the processed data obtained for 6 years, an average pressure reduction of 1.5-2 psi/month from the reservoir pressure occurred. As it is clear in Graph No.01, at the begging in late 2009, the average reservoir pressure was above 1200 psi, while this gradually decreased to 1160 psi.

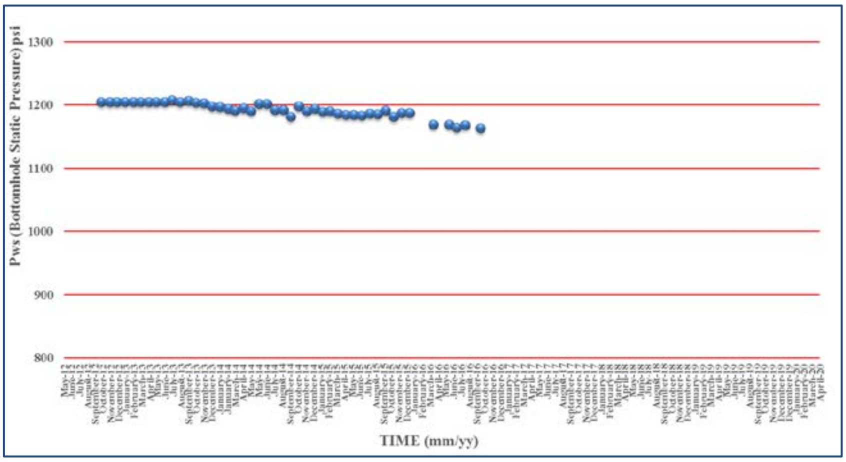


Figure 3: FK-OILFIELD PRESSURE PROFILE HISTORY [14]

4. Production history of the field

The FK-OILFIELD is being producing oil from around wells including oil wells and High GOR wells. This has dramatically effected on the pressure declining, as illustrated in the Graph No.02, the produced oil significantly increased from the whole field starting from 7000 BBL in 2009 to 200,000,000 BBL in 2016 [14].

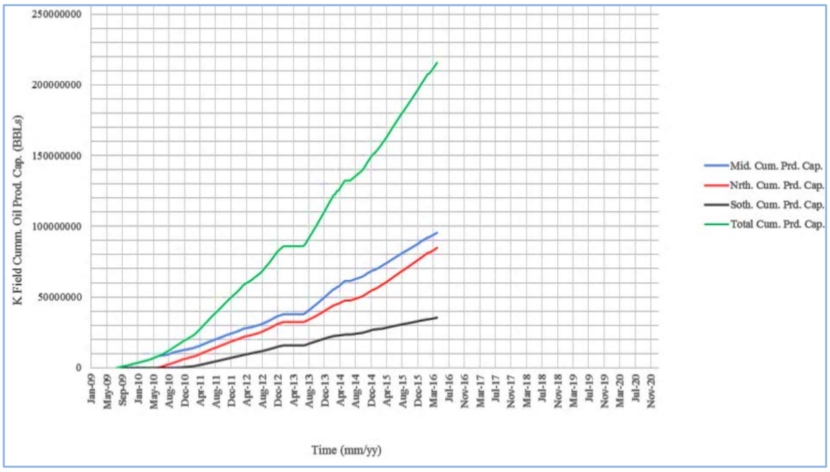


Figure 4: Cumulative Oil Production of K Field [14]

5. Procedure for Applying PROSPER Software based on NODAL Analysis Approach [10]

Determine which components in the system is supposed to be changed. Changes are limited in some cases by previous decisions. For example, in this case the pressure of the reservoir is analyzed. Select one component to be optimized, and this component is Reservoir Pressure. The bottom of the well is indicated as node location, because this point distinguishes the two important different flow systems (Radial system within the porous media and one-dimensional flow within the wellbore up to surface facilities) [4].

Develop expressions (graphs) for the inflow and outflow as shown in the below figure.

Obtain required data to make sensitivities for future prediction of reservoir pressure reduction.

Once the node is selected the node pressure is calculated from both directions at the fixed pressures as below:

Inflow to the node:

$$P_R - \Delta p\ (upstream\ components) = P_{node}$$

Outflow from the node:

$$Psep + -\Delta P\ (downstream\ components) = P_{node}$$

6. Current Well Capacity from IPR/VLP Operating Condition Point

The flow capacity of each well can be obtained from the intersection point between IPR and VLP curve using well test data; mainly through flow rate and pressure parameters. The studied well is modelled in PROSPER and the following Figure is obtained and it shows of having natural flow under current well test data [3].

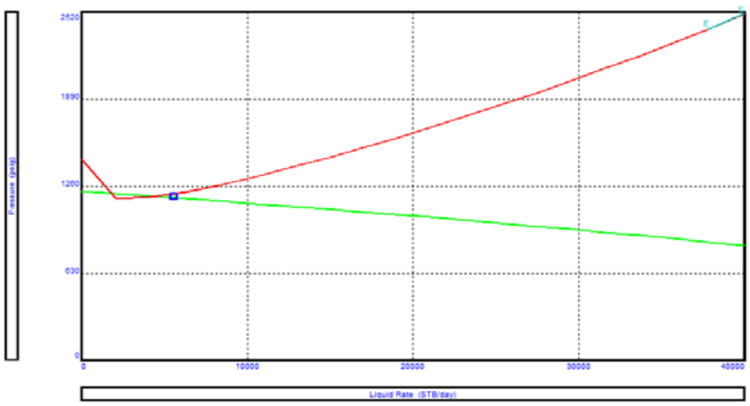


Figure 5: Current IPR vs. VLP Curve of FK-OILFIELD WELL [3]

From the curve and wells system capacity the below table contains the wells' production parameters such as; oil rate, gas rate, solution node pressure (Bottom-Hole Pressure) and water rate.

Table 1: Current Well Flowing Data

Liquid Rate	4441.2	(STB/day)
Oil Rate	4441.2	(STB/day)
Water Rate	0	(STB/day)
Gas Rate	1.750	(MMscf/day)
Solution Node Pressure	1185.71	(psig)

7. Future IPR/VLP Trend Intersection Under Reservoir Pressure Sensitivity.

As shown in figure 3.0 of pressure decline curve of the FK-OILFIELD taken from the field measurement data, the reservoir pressure from the begging of production since 2009 around 70 psi loosen from the reservoir pressure which was 1230 psig and now about 1160 psig. Consequently, considering this pressure reduction on IPR/VLP Sensitivities within the PROSPER Software would result in the following IPR Curves only [4].

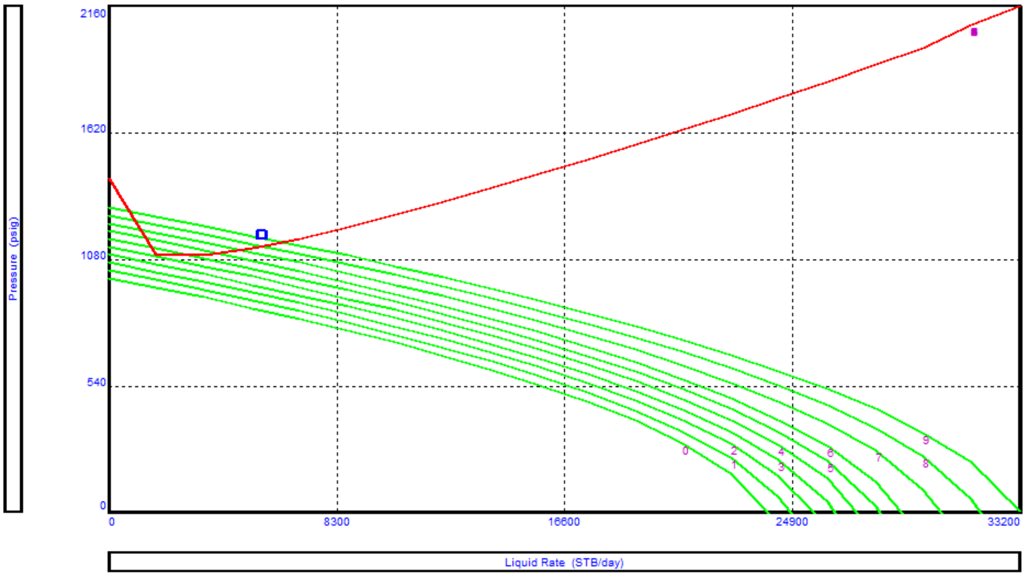


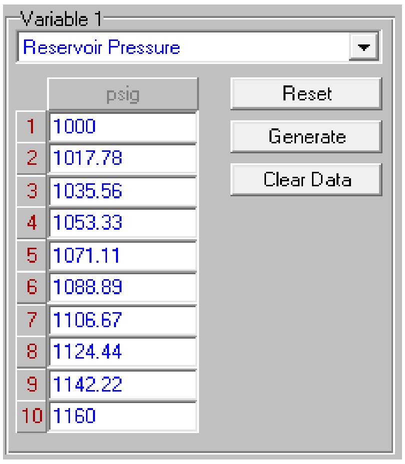
Figure 6: Current IPR vs. VLP Curve of FK-OILFIELD WELL

8. Results and Analysis

8.1. Reservoir Pressure Sensitivity Results

A reservoir pressure sensitivity between 1160 psig of current status and future prediction of having 1000 psig is tried in the Simulator Software for identifying the future results of pressure declining of the reservoir of FK-OILFIELD. The below Table is what is been tried on the pressure sensitivity of Variable 1 within the PROSPER:

Table 2: Variable 1 / Pressure Sensitivity



	psig
1	1000
2	1017.78
3	1035.56
4	1053.33
5	1071.11
6	1088.89
7	1106.67
8	1124.44
9	1142.22
10	1160

Having looking at the pressure sensitivity figure 6.0 below from the PROSPER Model, it is clear that the operation condition point is valid at solution node of the intersection between IPR and VLP Curves only when reservoir pressure above 1088 psig. Therefore, under situation of having reservoir pressure less than 1088 psig, the IPR will not intersect with VLP. Consequently, the natural flow through pressure depletion will not remain.

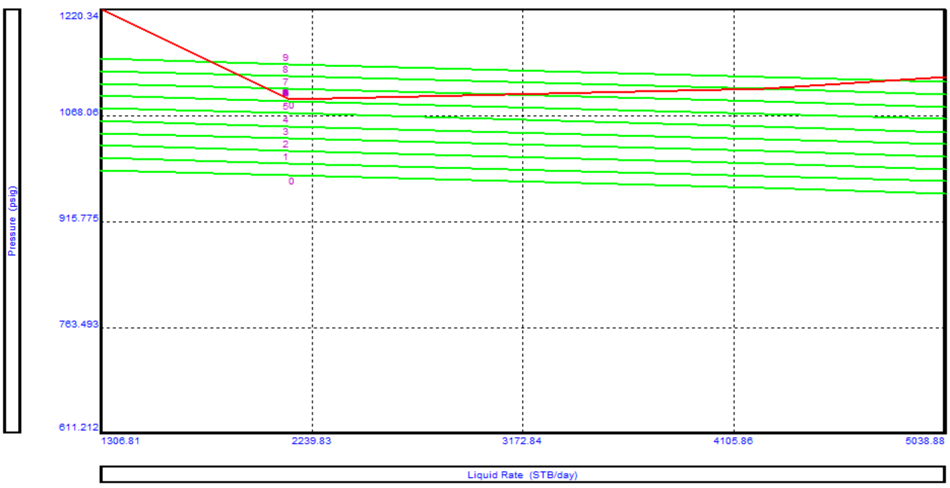


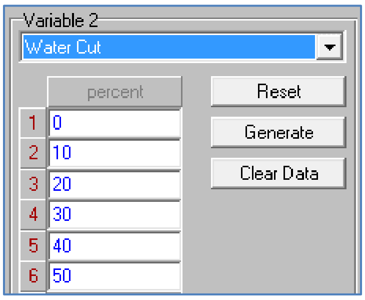
Figure 7: Current IPR vs. VLP Curve of FK-OILFIELD WELL [3]

8.2. Water Cut Resistivity Results [3]

Water cut is another production problem which connate reservoir water from the water encroachment system infiltrates to the bottom-hole of the well and consequently to the surface facilities. Thus, the oil rate will reduce because WLR increases. Hereby, having a greater amount of water produced within the oil flow strictly near the wellbore will affect the segregation process between hydrocarbons and water. This situation in the studied field is observed due to pressure reduction at the subsurface of the field, because the lower the pressure at the Gas Cap and oil zone, more water encroachment invades the completion interval. Additionally, W.O.C lifts up in relative to G.O.C.

Water conning unlike reservoir pressure reduction will also affect the VLP Curves causing the VLP Curves to shift upward and hence resulting in the difficulty of reaching to the operation condition of wells system capacity under natural flow. In PROSPER software variable 2 of system VLP/IPR curve is allocated for additional sensitivities and/or changes in the reservoir parameters such as water cut, GOR, Piping radius and node pressure. In this well of FK-OILFIELD water cut is tried with a range between 0-50% as shown in the below table:

Table 3: Variable 2 / Water Cut Sensitivity [3]



Variable 2: Water Cut

	percent
1	0
2	10
3	20
4	30
5	40
6	50

The IPR/VLP intersection point is only appear when WC<20%; because the VLP Curves as shown below moving away from the operational condition point [3]

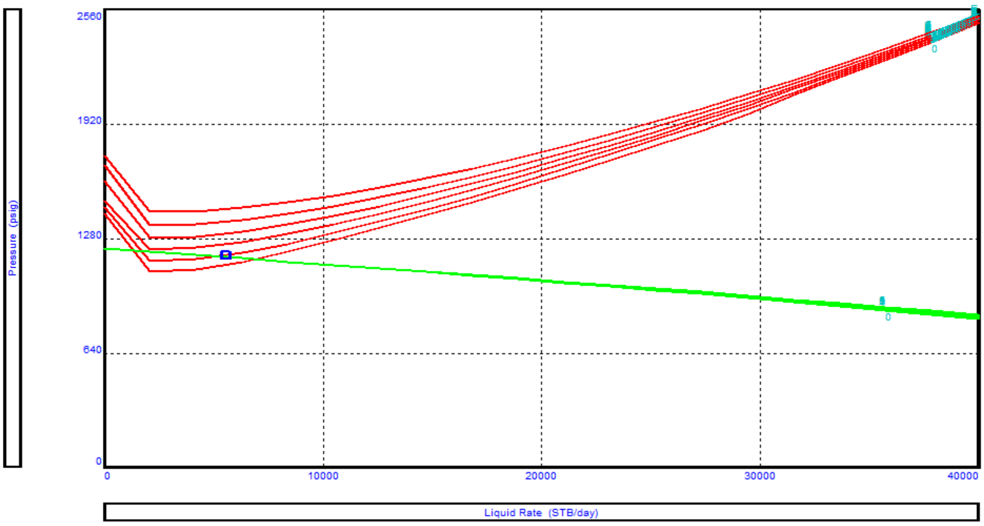


Figure 8: Current IPR vs. VLP Curve of FK-OILFIELD WELL [3]

9. Conclusion

PROSPER Simulator is one of the Production package of IPM and it is one of the applicable methods for monitoring the production performance of oil wells this work in carried out through modelling an oil well through using PROPSER with in cooperating of Slickline unit where bottom-hole memory gauge device is continuously or from time to time is RIH through tubing and/or production casing at selected wells. This has produced the required test data for matching with one of the VLP Correlations.

In production engineering, various tasks are required to be obeyed, one of these tasks is the monitoring the change in the level of the flow rate under natural. Therefore, this work is carried out as a requirement of production engineering tasks in one of the oil fields in Iraq. Natural flow is monitored through observing solution point of intersection between IPR and VLP, where the FK-OILFIELD Well produces 6873 bbl/day oil rate under solution node pressure / bottom-hole pressure of 1164 psig with zero water cut. The selected well after modelling the well in PROSPER Model and processing bottom-hole data for two different sensitivities of Reservoir pressure as Variable 1 and Water Cut/Water Conning as Variable 2. Consequently, two different IPR/VLP curves were produced for the two mentioned cases of variable 1 &2 within the system two variables. Under case one when reservoir pressure declines with free water cut, the minimum pressure is 1088 psig for producing through naturally depletion, whereas, if the water cut appears the maximum percentage of water producing is 10% of total gross liquid ratio. Finally, the Prediction of water injection time for the studied field to sustain the natural flow through using PROSPER-IPM software is expected to be within the next three years if the production capacity remains above 100,000 BOPD. This situation; should be tackled through the first step of water injection for supporting reservoir pressure.

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