RESEARCH ARTICLE

Oil Well Testing Using a Production Logging Tool in the Khurmala Field in Kurdistan Region, Iraq

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ABSTRACT

Production logging tools (PLTs) in oil and gas industries are used for obtaining fluid types and measuring fluid rates in the borehole for both production and injection wells and to better understand the well productivity or the well injectivity of the interest zones. Additionally, it can be used to detect well problems, such as early water or gas breakthrough, channeling behind casing or tubing, and water or gas coning. The Khurmala field is a big oil field in the Kurdistan region of Iraq. PLTs have been acquired in many of the Khurmala oil wells, and the log records took into consideration the production technique decisions. In this study, results of the PLT log will be discussed in one of the Khurmala oil wells. Owing to the long history of production of oil or gas wells, many problems have been seen, such as coning either water or gas, formation damage, casing corrosion, and well obstruct. This research will evaluate the production profile across the slotted liner interval of (W1) well in the Khurmala oil field in the Iraq-Kurdistan region and detect possible water entry points, verify the distribution and nature of fluids, and estimate fluid segregation after the shut-in period. This was done by applying PLTs and interpreting the data by using Emeraude software. The performance of each choke size was studied and assessed. It was found that a choke size of 48/64" gives the best favorable production gas, oil ratio, and profile. Results from the PL survey showed that no water entry was detected across the logged interval. All the water was coming from below a depth of 990 m; most of the hydrocarbons were coming from the slotted interval across 981.8-982.9 m, and the flowing pressure across the logged interval using maximum choke was less than the saturation pressure.

Keywords: Production logging tool, Well test, Choke size, Wellhead pressure

1. INTRODUCTION

Nowadays, in the Khurmala oil field, hydrocarbons are being produced from the well using the natural reservoir pressure only. Well life has been challenged owing to the long production time, and the wells have been affected and have lost their initial properties, suffering from problems, such as wellhead pressure, casing integrity problems, and oil flow rate that is directly related to the area of the pay zone. This has all been

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a result of mismanagement and poor well study of the well performance. These problems were taken into consideration, and therefore, a production logging tool (PLT) was considered to be used in the Khurmala oil wells before deciding to do workover jobs. Using production logging to decide on the stream of oil, gas, and water phases is central to get an idea about production problems and workover programs. Production logging is a record of one or more in-situ measurements that describes the nature and behavior of the fluid around the borehole during production or injection. It is the measurement of fluid parameters that are the foundations that yield information about the type and movement of fluid around the wellbore. The primary aim of a PLT is to measure the performance of producing wells. The research will provide analytical information about the different fluids, such as water, oil, and gas, that enter a well, and PLTs gives signals about the efficiency and productivity of the perforations. Mckinley (1982) showed that traditionally reservoir and subsurface engineers use the PLT however, due to the increasing of threats of drilling it's of a great importance by drilling engineers and it can't be ignored. Production logging tools detect problem wells as we as reservoir surveillance it should be run before a well is perforated for production. Traditionally, there are four measurements in which production logging is involved, namely, flowing, flow density, temperature, and pressure. The flow and density readings were used in traditional quantitative production logging, while an analysis of temperature and pressure data has normally been used in a qualitative way to calculate in-situ flow properties and detect zones of entry of fluid into a well. Modern production logging is very different than the old one. It has been redesigned and developed and additional highly accurate sensors have been added in a single tool. Now PLT is run for different purposes, such as monitoring and controlling the reservoir, analyzing dynamic well performance, productivity of different zones, diagnosing problematic wells, and monitoring the results of a stimulation or completion. The latest tool uses a new technology to measure the flow profile for the individual fluid phases all around the borehole. Production logging is used in all stages of the life of a well. It is run into cased hole initial completion or injection wells with or without tubing and also in secondary recovering production wells. This study will evaluate the production profile across the slotted liner interval of (W1) well in the Khurmala oil field and detect possible water entry points, verify the distribution and nature of fluids, and estimate fluid segregation after the shut-in period. This was done by applying a PLT and interpreting the data by using Emeraude software.

2. THE PURPOSE OF USING A PRODUCTION LOGGING TOOL

- Production profiling: To profile the well; to find if it is performing normally.
- Injection profiling: To decide the profile of injected water or gas of the injection wells.
- Excessive gas problems: Gas coning is bad and limits the stream of the oil; so, if the area of the source of that gas production is found, it can be controlled.
- Water problems: A vast majority of the productions logging jobs are done because of the production of undesirable water. At a point when the volume of produced water expands sharply from a zone, it would decrease the production rate of hydrocarbons. (Whittaker, 2013).
- Mechanical problems: Any problem in the tubing or casing can be detected and found; similarly, it is used to distinguish blocked perforations.

3. PROCEDURE AND INTERPRETATION USED FOR PRODUCTION LOGGING TOOLS

The procedures will be presented as two main steps:

I. Programming the Job

This part is the most important part; there should be a good coordination between engineers and well operators. First, the problems must be defined such as channeling, saturation, falling of oil production, and increasing of water cut.

II. Running the Job

In this step, tools will indicate the following:

I. Tools calibrating
II. Depth maintaining
III. Data recording

4. INTERPRETING THE DATA

Usually, interpretations are done with computers using Emeraude software, which is for two types of interpretation models: for single phase (only one type of fluid) or multi-phase (two types of fluids such as water/oil fluid). See Figure 1.

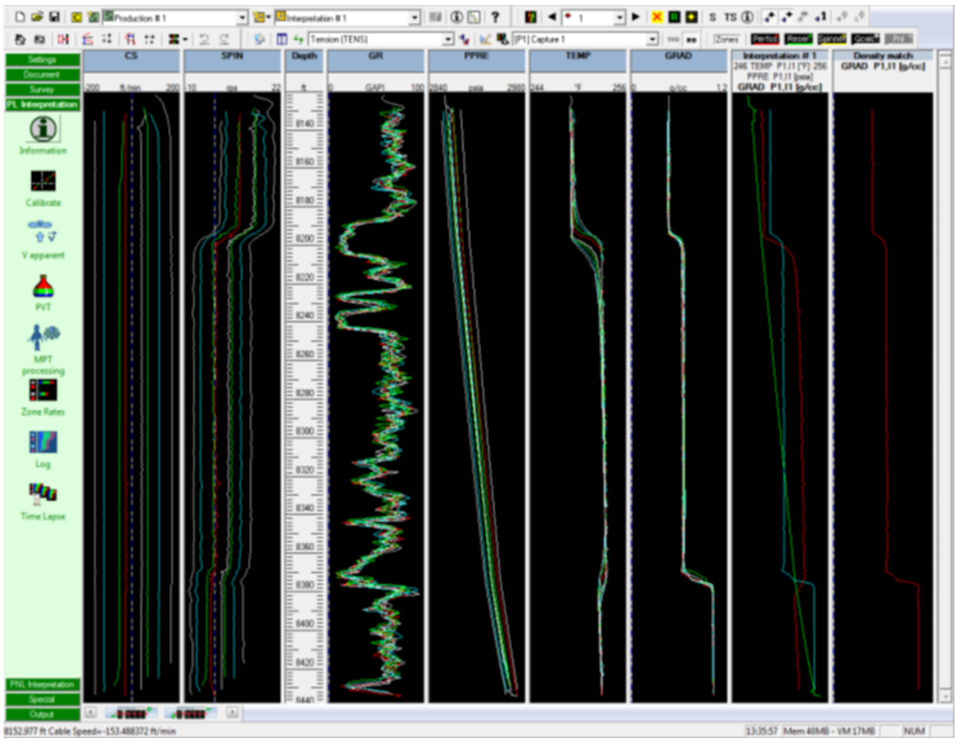

Figure 1. Main screen of interpretation (Emeraude, version 2.60, KAPPA, 2010)

5. APPLICATIONS OF PRODUCTION LOGGING TOOLS

PLTs are used after the well is drilled and during production until the well is abandoned, for determining various applications that are responsible for the development of modern PLTs. The most important applications of PLT are explained as follows:

1- Allocating productions and identifying the problems: The tools that are used for these purposes are temperature log, flowmeter, fluid density log, and gradiomanometer. The tools' reactions are to both velocity and fluid type; thus, it can track the movement of fluid inside and outside the casing of the well.

2- Cement placement monitoring: Using this application for checking the cement to see if it isolates the zones and to locate the cement top. The logs were used for are; temperature log and gamma ray log.

3- Cement corrosion monitoring: Cross-flow through poorly cemented areas results from the inequality in the hydrostatic pressure and formation pressure. For this purpose, the following tools were used: cement bond logs, temperature log, Noise logs, radioactive tracer log, and Neutron activation logs. Cement bond logs were used to find the integrity and quality of cement. Temperature log was used to identify changes caused by flow. Noise logs measured the turbulent sounds caused by flow. The radioactive tracer log located the fluid behind the casing. Neutron activation logs traced the water behind the pipe (Smolen, 1996).

6. FIELD DATA PROCESSING

a. The production logging surveys were performed on an electric line, a vertical well completed with slotted liner Spartek PL tools.

b. The objectives of the logging program are as follows:

    1- Evaluate the production profile across the slotted liner interval and detect possible water entry points.

    2- Verify the distribution and nature of fluids.

    3- Estimate fluid segregation after the shut-in period.

c. The well was logged at shut-in and three flowing rates: 32/64, 48/64, and 64/64 chokes.

d. There were six passes down and up at different cable speeds (10, 20, and 30 m/min) across the interval during the flowing survey.

e. Before these passes, the shut-in and flowing surveys were tried on February 19th, but owing to spinner damage, the job could not be completed, and it was decided to start it over again after spinner replacement. Shut-in data during the 1st run out of hole showed that the spinner collapsed around 994 m owing to some unknown restriction; so, during the 2nd run in hole, it was decided not to go down below 990 m as the chance of spinner damage could be high.

f. The acquired data are considered to have good quality in seven casing.

g. These surveys had been run to cover slotted liner intervals in this well. The slotted interval as per well sketch provided by the KAR GROUP is 982.7-996.7 m.

h. The production profiles have been made based on the spinner, temperature, and capacitance responses in flowing surveys.

i. Sump level could not be detected by capacitance and acoustic density during the static condition as the bottom of well could not be reached.

j. No cross-flow was detected during shut-in conditions. Stable and repeatable pressure, capacitance, and density (apart from the density of first up and first down passes) support the fact that there was no cross-flow. Different readings on temperature for up and down passes were due to hysteresis effect.

k. The spinner data of all the flowing surveys were increased up to 981.8 m, while from the well sketch, the slotted liner top was 982.7 m. As all the logs were cross-checked several times with the reference logs, it could be noticed that the well sketch needed to be updated as the slotted liner might have been off depth by about 1 m.

l. A small amount of water was seen during the flowing surveys but no signs of water was seen across the logged interval.

m. Figure 2 shows the density, temperature, and pressure of all the surveys together. As can be clearly seen from the image, the inflow zones were producing some gas during the flow on 64/64 choke. The lower density of 64/64 choke compared with the other two flows confirms this.

The selective inflow performance (SIP) plot for each flow zone was made using four points (one shut-in and three flowing rates) for hydrocarbon production at surface condition. The good spinner data quality and the well stability in terms of pressure and flow rate increased the confidence level of the SIP plots.

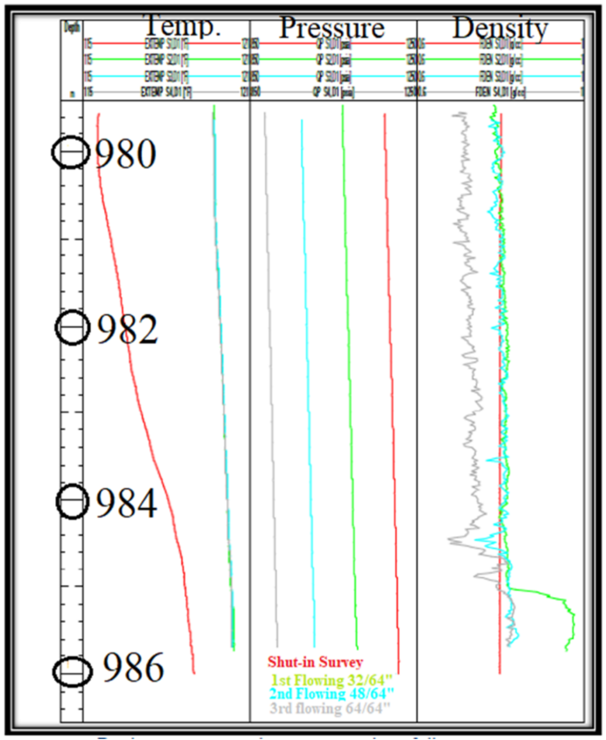

Figure 2. Density, temperature, and pressure comparison of all survey

7. PROCESSING THE RAW FIELD DATA

The Spartek PL tool was used with wireline (Gama Ray (GR) and Collar Casing Locator (CCL), acoustic density, full bore and in-line spinner, dielectric, pressure, and temperature). The spinner data were considered to be of good quality with constant cable speed. The spinner calibration slopes and thresholds were obtained from each survey. The spinner slopes among the surveys were consistent with low spinner thresholds in water and oil zones (Schlumberger,1989). The fluid density was obtained from the acoustic density tool and pseudo density (dp/dz). The pressure volume temperature properties of fluids were provided by KAR GROUP CO. The well bore pressure readings were quite stable and repeatable between passes (pressure variations of around 5 psi between passes) in all surveys. The averaged data pressure from the passes was used for calculating input. The fluid density was obtained from ADT and pseudo density (dp/dz). The ADT density was repeatable during most of the surveys. The ADT data were qualitatively consistent with capacitance data. The dielectric or capacitance was run in the well. The dielectric/capacitance data were fairly considered repeatable between passes and surveys, as in terms of flow regime, the well was not stable. Both capacitance/water holdup and pseudo density data were used for water holdup calculation in Emeraude software. The water hydrocarbon (L) flow model was used for this interpretation to accommodate the possible water presence in the wellbore. There was small water production at the surface during the flowing survey.

8. SHUT-IN SURVEYS

Table 1 shows the PLT value at the calibration condition zone, while Table 2 shows the production rate at each phase (Mohammed, 2017).

Table 1: The PLT value at the calibration condition zone

Calib. Zone M	Slope (+)	Slope (-)	Int (+) ft/min	Int (-) ft/min	Int. Diff. ft/min	Thr. (+) ft/min	Thr. (-) ft/min
968.4-973.0	0.068	0.060	2.44	-0.54	2.99	0.00	0.00

Table 2: The production rate at each phase

Zones m	Water STB/D	Oil STB/D	Gas Mscf/D
Inf. 1 (987.9-988.5)	0.00	0.00	0.00
Total (inc. bottom)	0.00	0.88	0.22

9. FIRST FLOWING SURVEYS 32/64''

Figure 3 shows the production rate using the choke 32/64" for the production of each, oil, gas, and water. It was measured at an interval of 981.8-990 m, as it was seen at an interval of 981.8-982.9 m; the production of oil was 877 bbl/D, gas was 224 Mscf/D, and water was zero.

Although at a depth of 985.1-985.9 m, oil production and gas production were dropping to 219 bbl/D and 56 Mscf/D, respectively, while water was still zero. All production was reducing to zero at an interval of 990 m.

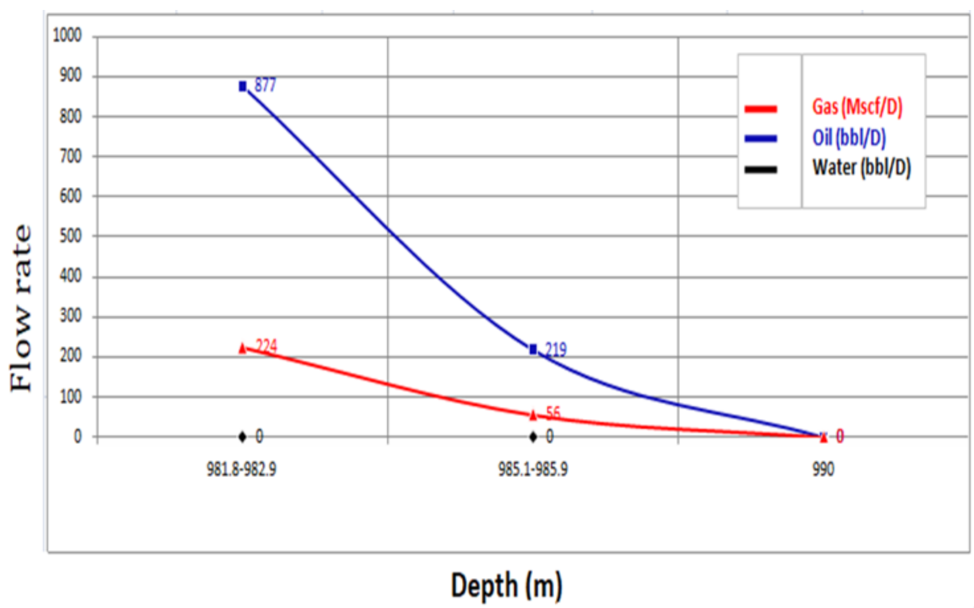

Figure 3. First flowing using choke 32/64"

10. SECOND FLOWING SURVEYS 48/64''

Figure 4 shows the production rate when the choke was opened to 48/64" for production of each, oil, gas, and water. During the interval (981 m), oil production was 1834 bbl/D, gas production was 479 Mscf/D, and water was zero. When coming down to 985 m, the production rate reduced to 262 bbl/D for oil and 68 Mscf/D for gas. The production rate was zero during the interval of 990 m.

11. THIRD FLOWING SURVEYS 64/64''

While opening choke to 64/64", the rate of production was going up to about 2037 bbl/D for oil and 693 Mscf/D for gas, while water was at zero in the interval of 981 m; see Figure 5.

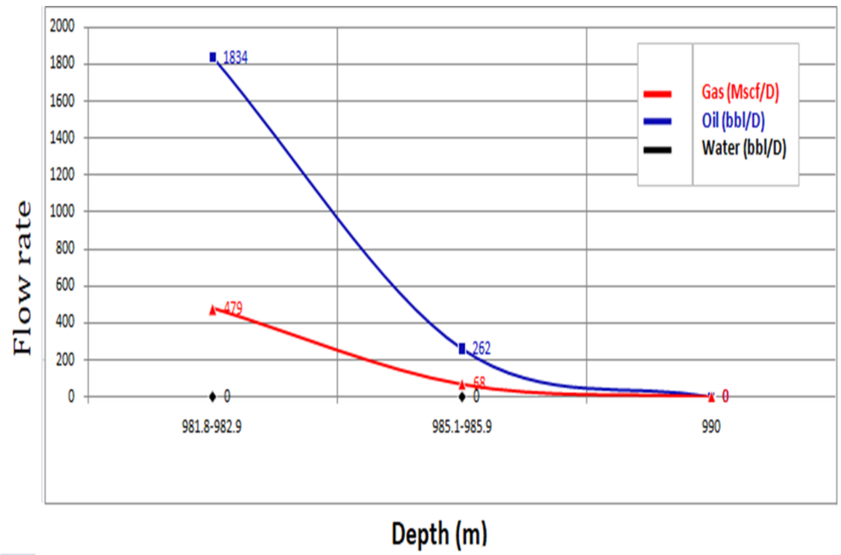

Figure 4. Second flowing by choke 48/64"

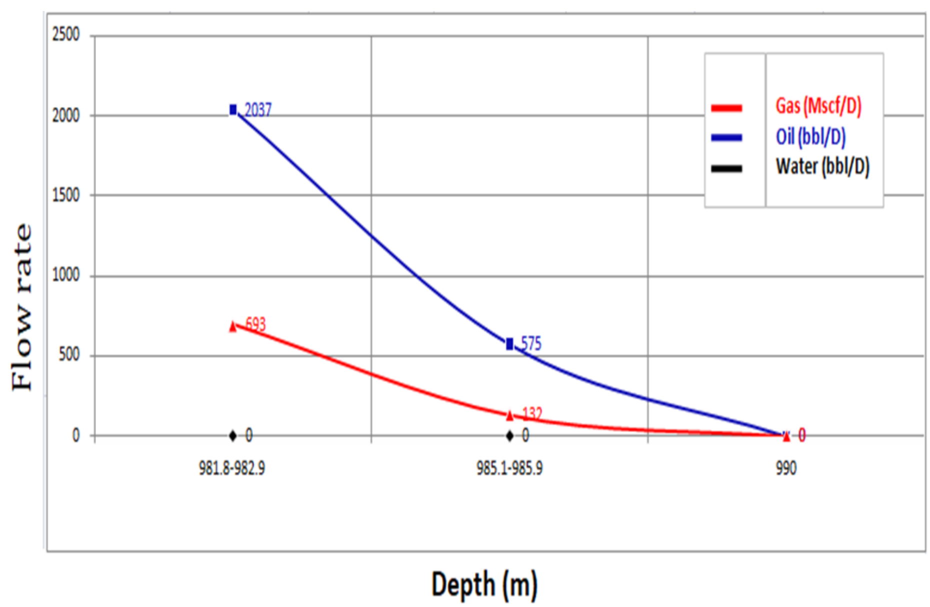

Figure 5. Third flowing by choke 64/64"

Figure 6 shows the combination of all the previous three scenarios, and as can be seen, oil flow rate as well as gas flow rate during first flowing is much smaller than the second and third flowing, that is, the highest oil and gas production was coming from third flowing during the intervals of 981.8-982.9 m.

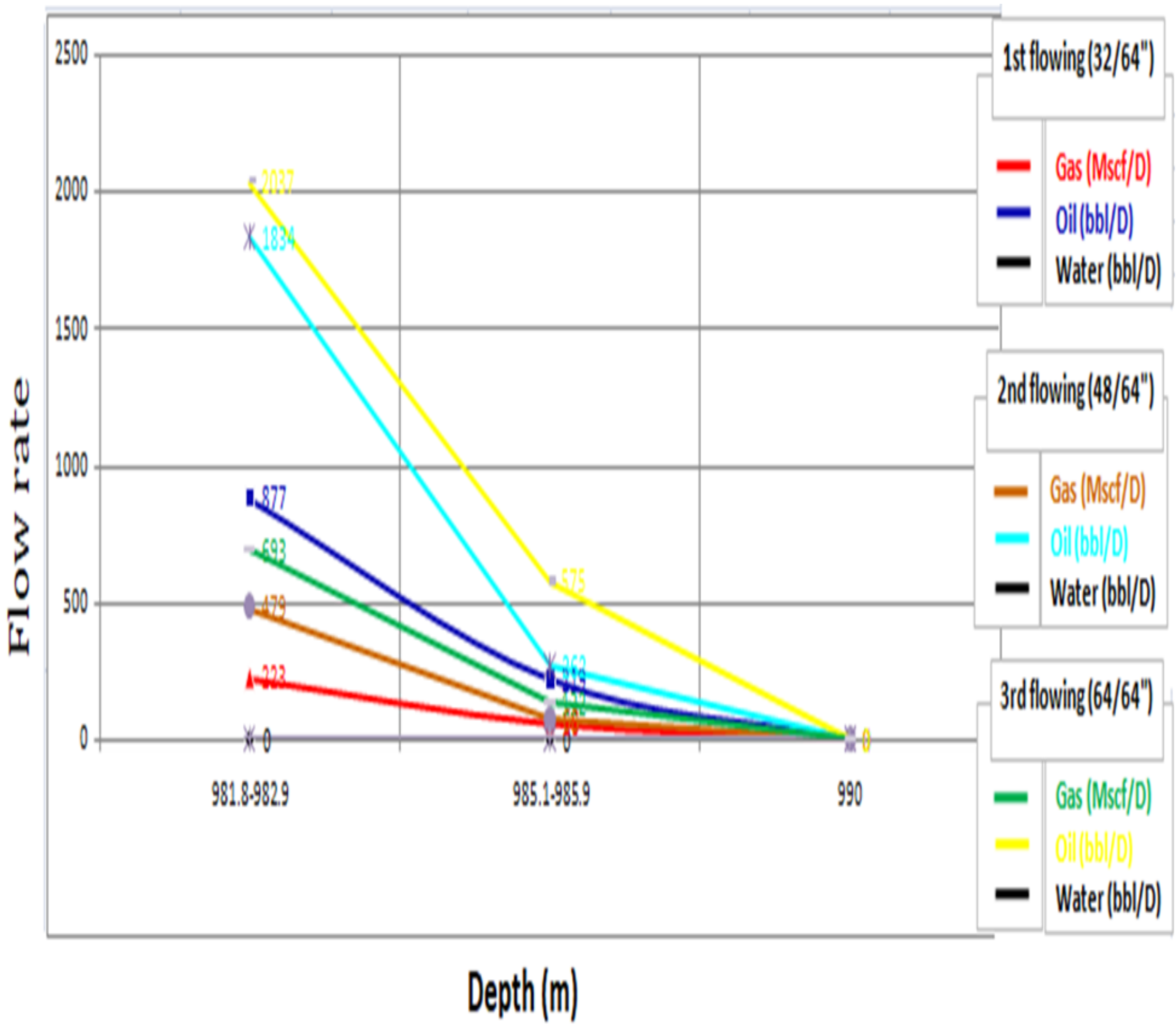

Figure 6. **Combined three scenarios**

Figure 7 shows the cumulative fluid gross production of all four surveys during different intervals. It can be seen that the rate of production is around 2900 bbl/D when using choke 64/64” during intervals of 981.8-982.9 m, which is the maximum rate of production when compared with other surveys.

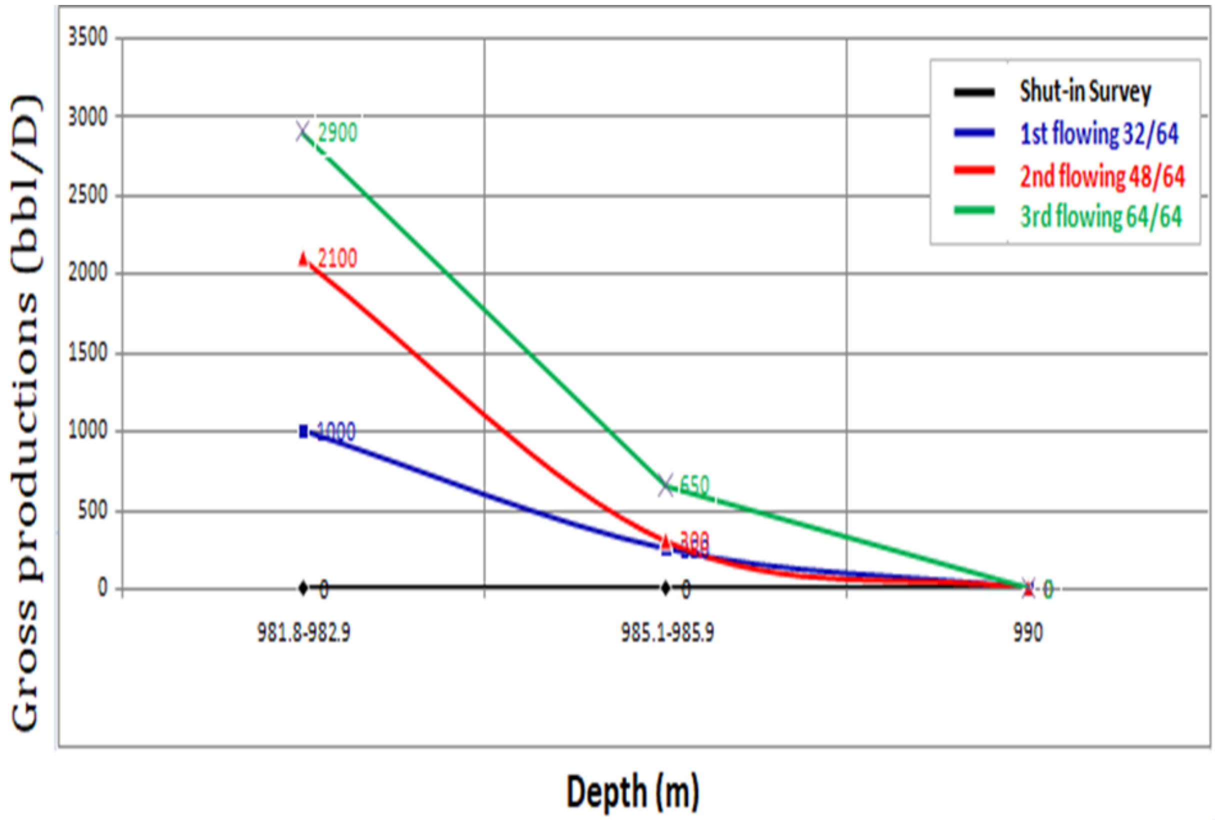

Figure 7. Cumulative gross production

12. RESULTS AND DISCUSSION

- Figure 2 shows the density, temperature, and pressure of all the surveys together. As can be seen from the figure, the inflow zones were producing some of the gas during the flow on the 64/64” choke. A lower density of the 64/64” choke compared with the other two flowing confirm that.

- The SIP plot for each flow zone was made using four points (one shut-in and three flowing rates) for hydrocarbon production at surface conditions. The good spinner data quality and the well stability in terms of pressure and flow rate increased the confidence level of the SIP plots.

- A shut-in survey was tried during both of the runs in holes. Cross-flow was not detected during a static condition.

- During the last flowing survey, a mixture of gas and oil was flowing from the slotted interval, which confirms that during the maximum choke, flowing pressure was less than bubble point pressure.

- The interval below 990 m was producing a little amount of hydrocarbons during the maximum and medium chokes, while production from this interval was negligible during the minimum choke.

No sign of water entry was detected across the logged interval; all the water was coming from below 990 m.

13. CONCLUSION

The PLT was used on well (W1) in the Khurmala oil field at a depth of 981.8 m. Measurements were taken through the used PLT tools, and data were interpreted through Emeraude software for determining the following:

1- The performance of each choke was studied and assessed, and it was found that a choke size of 48/64" gave the best favorable production of gas, oil ratio, and profile.

2- The study is an indicative method for identifying best production operation practices that safeguard well performance, the reservoir structure, and extend well life with optimal recovery. Using a choke size of 64/64" shows production of oil and gas as well as water; the produced water is undesirable as it needs further surface processing and separations, which would incur high costs for the operator. The produced water is a source for pressure loss of the well. This pressure could be used for producing hydrocarbon. With the third choke (32/64"), the production profile was limited to gas and oil with no water production, for the well is low owing to a small choke size. In the second scenario, with a choke size of 48/64", we experienced a production profile of gas and oil with no water. This gave us a high rate of production with no water being produced.

3- Conclusions from the PL survey can be summarized as follows:

- No water entry was detected across the logged interval. All the water was coming from below 990 m.
- Most of the hydrocarbon was coming from the slotted interval across 981.8-982.9 m.
- The flowing pressure across the logged interval on maximum choke size was less than the saturation pressure.

4- During the flowing, three scenarios were analyzed:

- In the 1st scenario, when the choke was set to 32/64", the production rate in the zone 981.8-982.9 m was no water and no gas available, and oil rate was 1000 bbl/D.
- In the 2nd scenario, when the choke was set to 48/64" in the same zone, the production rate of gas and water was zero, and the discharge of oil was 2100 bbl/D. This scenario is the recommended one as it extends the production period and also the well life.

In the 3rd scenario, when the choke was set to 64/64" also in same zone, the production rates were a small amount of water, but was not recorded because it is less than the sensors reading with rate of gas was 600 bbl/D and oil discharge was 2300 bbl/D.

RECOMMENDATIONS

I. Links with Halliburton software to provide a complete interpretation, including phase flow rates at both the downhole and the surface.

II. Advanced and modern tools recommended for running during the drilling, such as an electromagnetic propagation tool, which is used to measure the propagation of the time when this transmission is variable from water, oil, gas, and matrix in the reservoir as well as can measure the cementation exponent (m) to get more accurate results and new data for the Khurmala oil field in the Kurdistan Region, Iraq.

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