Journal of Petroleum Research and Studies

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

DOI: http://doi.org/10.52716/jprs.v13i4.741

The Optimum Production Management for Production Problems in Sadi Reservoir of Halfaya Oil Field

Ameer H. Hashim[1*], Mohammed S. AL Jawad[1], Kassem A. Khlaty[2]
[1]College of Engineering, University of Baghdad, Baghdad, Iraq
[2]Ministry of Oil, Petroleum Research and Development Center (PRDC), Baghdad, Iraq
[*]Corresponding Author E-mail: ameer.hashim2008m@coeng.uobaghdad.edu.iq

Received 29/01/2023, Revised 14/02/2023, Accepted 28/02/2023, Published 12/12/2023

Abstract

Tight oil reservoirs suffer from a high decline in flow rates and instability of production rates, even after implementing the hydraulic fracturing technique to increase the production rate, but the problem still stands and needs to be overcome. This issue is found in the southeast of Iraq in the Halfaya oil field, especially in the Sadi formation.

The goal of this study is to identify an optimum production rate for horizontal and vertical hydraulic fracturing wells using simulator software for prediction, in order to avoid highly depleted fracture storage capacity, which results from high production rates and depletion in flowing pressure. as well as to discuss the production behavior of the wells over their life cycles in the Sadi reservoir. In addition, we utilize a novel approach with production rates for horizontal hydraulic fracturing wells to reach a stable production rate.

The results show that the production behavior of hydraulic fracturing wells is clear: producing at a high flow rate depletes the fluid potential of a fracture without providing a reservoir with an opportunity to compensate fluid into fracturing potential. In horizontal hydraulic fracturing wells, conducting an allowable flow rate that satisfied stability.

We conclude a suitable flow rate has been identified to avoid high depletion rates and the plateau rate was different than that detected by the operator company, and we advise on future hydraulic fracture well development.

Keywords: Production Optimization, Hydraulic fracturing, Reservoir Simulation.

1. Introduction:

Tight oil reservoirs are a hot spot in the investment world. The Sadi formation of the Halfaya oil field in southeast Iraq, which is considered a tight oil reservoir with low porosity and low

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

permeability, suffered from low production rates and flowing pressure below bubble point pressure. Therefore, there are several attempts to develop them by implementing hydraulic fracturing techniques in spite of doing fracking to improve productivity in the Sadi formation, but still there are issues associated with rapid depletion in flow rates and flowing pressure with elapsed time. Fluids flow in an unconventional formation is result a transient pressure response was illustrated by Ref. [1], finding that it takes a long time before the pseudo-steady state begins or perhaps the fracture interference period, begins. Ref. [2] explained that the fracture properties could change during the reservoir operation owing to fluid pressure changes, thermal cooling, and precipitation of minerals and decreased pressure during fluid extraction from the reservoir can cause fractures to close. There is a strong correlation between the length and permeability of fractures in a fractured horizontal well and the resulting output of fractured horizontal wells as illustrated by Ref. [3], focusing on creating longer fractures and increasing fracture conductivity when treating horizontal wells via fracturing is important for predicting the production performance of a hydraulically fractured horizontal well with multiple fractures. Integrated system introduced by Ref. [4] can automatically figure out production rates based on real-time pressure data, this method helps us determine the reservoir's productivity and ensures that the reservoir's model is always up to date with real and necessary data. Acid fracturing treatment and Hydraulic fracturing treatment techniques have been employed to increase well production rates in Halfaya field/Sadi reservoir by Ref.[5] using advance computer software to apply these two majors needs to be one of a successful job that can be adapted in all Iraqi fields, that are producing from Sadi formation.

In this study, we utilized a reservoir model with eight wells producing from the Sadi formation (Sadi-B1, B2, barrier layer ,and B3) with thickness averaged with 45, 104, 1, and 35 meter as per Ref[6], to investigate the purpose of this paper by focusing our investigation on the vertical and horizontal hydraulic fracturing wells.

The purpose of this study is to seek a suitable constant production rate above bubble point pressure slight decrease in flowing pressure from the start of production until the year 2025 through the first pilot vertical and horizontal hydraulic fracturing wells in the Sadi formation, identify if the plateau rate, which conducted by the oil field operator Ref. [7] is fitting for producing, and then detect the optimum flow rate that could satisfy stability for both production rate and flowing bottom hole pressure.

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

2. Optimization process methods

In this study a reservoir simulator model utilized and after finishing the history matching part as shown in Appendices A to D; the two wells (W-5 and W-6) show a good match with less anomaly, whereas the well (W-55) gave no identical match before doing hydraulic fracturing because the deferential pressure to deliver these rates is considered low in the simulator calculation and the measured bottom hole pressure is low, after doing hydraulic fracturing in 21-Dec-2016, there is a match with less anomaly because some readings in flow rate is too high to deliver, which gives a high error after converting to bottom hole pressure, we reached this match after several trying, Furthermore, well (W-52) matches in some points but not in others due to a low oil rate with a high gas rate as a result of gas being separated from the electrical submersible pump, resulting in a low bottom-hole pressure after converting well rates and pressure reading data to bottom-hole reading. we suggested different scenarios taking into consideration the practical and economical aspects of the selection. So, it was chosen as a limitation in suggested production flow rates for horizontal hydraulic fracturing wells, and these rates are 700, 900, 1300, and 1500 BOPD, which were conducted to achieve the desired purpose and find the best suitable flow rate from an economic and practical desired rate aspect that was called in our study the "optimum flow rate." These suggested flow rate implemented on horizontal hydraulic fracturing wells W-5 (eight stages) and W-6 (eleven stages), both wells penetrated in Sadi B-2, while the vertical hydraulic fracturing well (W-55) implementing different scenarios than horizontal wells, because of this well fracturing vertically through three stages and inability to provides the high flow rate although it penetrated the Sadi B-1, B2 and B-3 layers, the three scenarios suggested after end history matching in first of 2023 and start running with these scenarios from begging the year 2023 till 2025,these scenarios are:

a. The first scenario conducted to keep producing with last flow rate starting from begging the year 2023 till 2025.
b. The second scenario conducted by shut in the well for three months to check the discharging flow rate and pressure response.
c. The third scenario is constraining by keeping the production pressure above bubble point pressure to avoid gas evolved inside the reservoir formation.

The well (W-52) has very low production flow rate and flowing pressure and fracturing through vertical one stage in Sadi B2 formation and installing ESP after doing vertical hydraulic

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

fracturing and because of this, well cannot hold high flow rate we kept the well shut-in till the year 2025 due to this well conducted to be reperforated in the Sadi B1, B2, and B3 layers.

3. Production Optimization Processing

3.1 Horizontal Hydraulic Fracturing Well Performance

The suggested production in well (W-5) with a constant oil rate of 1500 BOPD in blue line, as illustrated in Figure (1), shows that there are matches in both the historical bottom hole pressure depicted by the black-blank balls and the calculated bottom hole pressure which depicted by dashed blue line. this rate conducted as a plateau rate according to PetroChina's calculations, the bubble point pressure has been reached in first 2021, after a shut-in period for static gradient survey getting recharge support in both liquid and bottom hole pressure. Bottom hole pressure cannot be maintained the production above bubble point pressure after Novamber-2020 according to simulator production indicators, and according to bubble point constrain will subsequently decrease to achieve an oil rate of 712 BOPD at the outset of 2025. The second suggested oil flow rate 1300BOPD in green line, we saw that the simulator bottom hole pressure line depicted by dashed green line, got closer to the historical bottom hole pressure, and this rate remained steady for the subsequent one and a half years. While the oil production at a rate of 900 BOPD by brown line is expected to continue until Feberuary-2024. At this point, it will begin to decrease until it approaches the bubble point pressure (Pb constraint) at the bottom hole of the well. if we producing an oil rate of 700 BOPD, the oil rate would remain steady with a minor decrease in bottom hole pressure as depicted in dashed red line, reaching 3439 psi until the beginning of the year 2025. Now we can recognize that the Petrochina Company's plateau rate is not identical to continuing with it, and the reason behind it is that production at a rate of 1500 BOPD is higher and will reach the bubble point pressure within one year. Higher production without giving an opportunity to reservoir to submit the depleted fluid into fracture storage. The optimal oil flow rate from an economic and production requirement standpoint is between 700 and below 900 BOPD for avoiding production below bubble point and maintaining continuous fluid inside fractures in a stable condition.

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

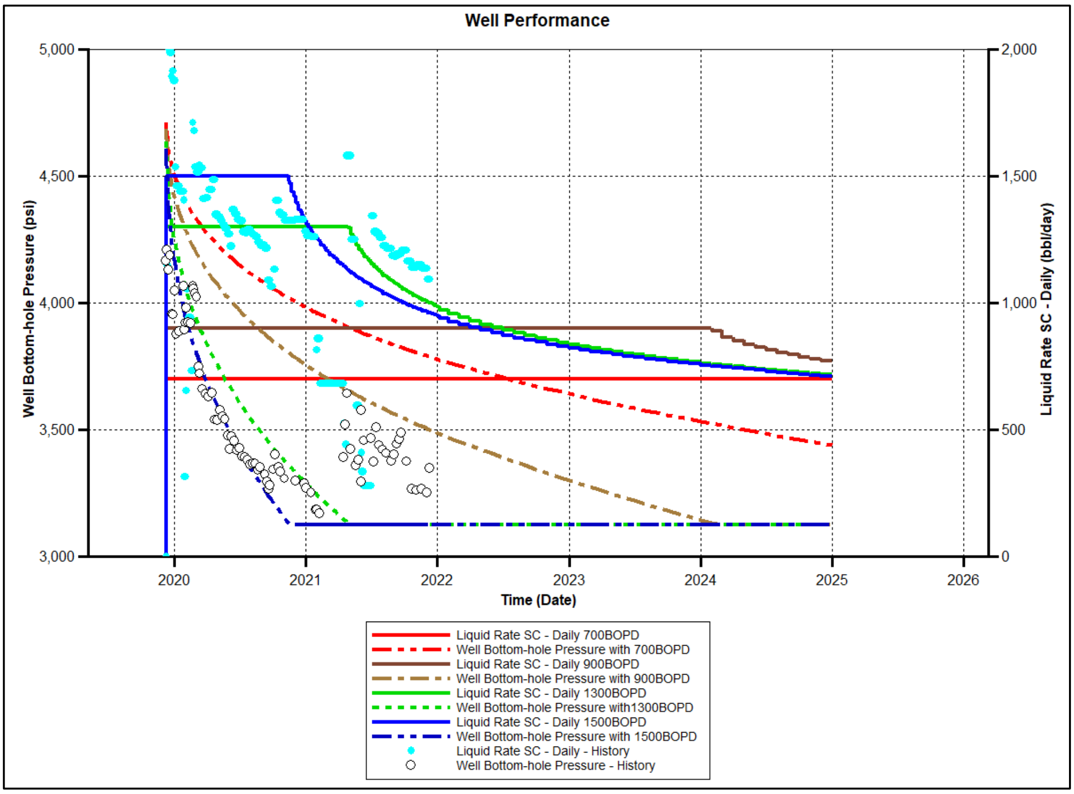


Fig. (1): Production Performance Scenarios for Well (W-5)

The same suggested flow rates in the first well (W-5) will be implemented in the second hydraulic fracturing well (W-6). The production rate of 1500 BOPD as shown in Figure (2), depicted by the blue line, indicates this rate cannot sustain stability for more than one year from the first commission until December-2021, then drop to reach an oil rate of 765 BOPD at the beginning of the year 2025.

There is a match between the flowing pressure of 1500 BOPD and historical bottom hole pressure, as producing at this rate causes production to drop below bubble point pressure after one year, which from the economic side is acceptable, but this will lead to depletion in mechanism drive and flowing pressure. There is consistent oil production at an oil rate of 1300 BOPD until August 2022, then it begins to decline until it reaches 777 BOPD in January-2025, This occurs once the production capacity reaches or exceeds the bubble point pressure. While producing oil at a rate of 900 BOPD until 2025, have a capacity to maintain this rate constant while achieving a bottom hole pressure of about 3191 psi. Starting production with an oil rate of 700 BOPD, giving stability in flowing pressure with a slight decline in bottom hole pressure reaching above 3500 psi till the beginning of the year 2025. Despite this rate, which is considered

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

low in the hydraulic fracturing process with eleven stages from the start of production, it can maintain a high level of pressure flow for several years without reaching bubble point pressure. The eleven stages can detect that producing with an oil rate between 900 BOPD and 700 BOPD is optimum from the first commission because these rates can achieve stability in production rate with a slight depletion in flowing pressure, but the important thing is producing above bubble point pressure.

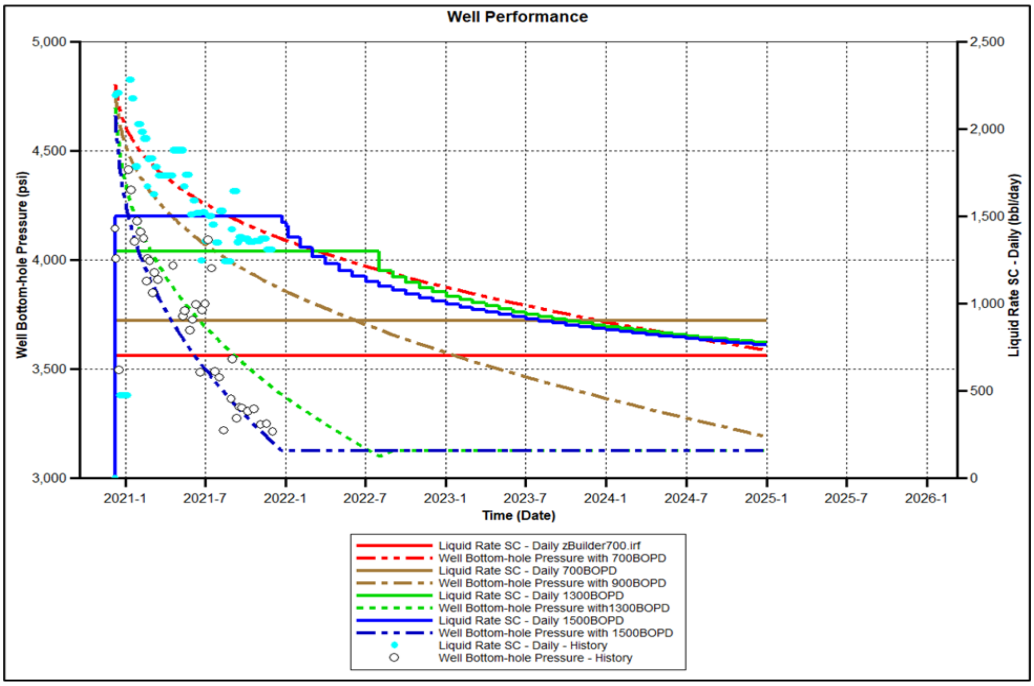


Fig. (2): Production Performance Scenarios for Well (W-6)

3.2 Vertical Hydraulic fracturing

The well (W-52) does not give any economic flow rate even after implementing vertical hydraulic fracturing through the vertical one stage in Sadi B2 formation. The well still has a weak flow, and after installing the electrical sub pump (ESP) on 02-April-2019, it cannot provide a high rate. This is a big problem when using ESP in a vertical hydraulic fracturing well in a tight reservoir because it will lead to speeding up the proppant production process, which causes a reduction in fracture storage capacity and does not give the reservoir the opportunity to compensate for the output fluid from the fracture storage capacity, so all the suggested scenarios cannot be implemented due to low conductivity, as illustrated in Figure (3). After a short period, observed down hole electrical failure, then shut-in for work over to ESP Pull out of a hole (POOH) on 14-December-2019 and still shut-in till 2022, Scheduled for reperforating in Sadi B2, B3, and Tanuma and converted to Gas lift well.

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

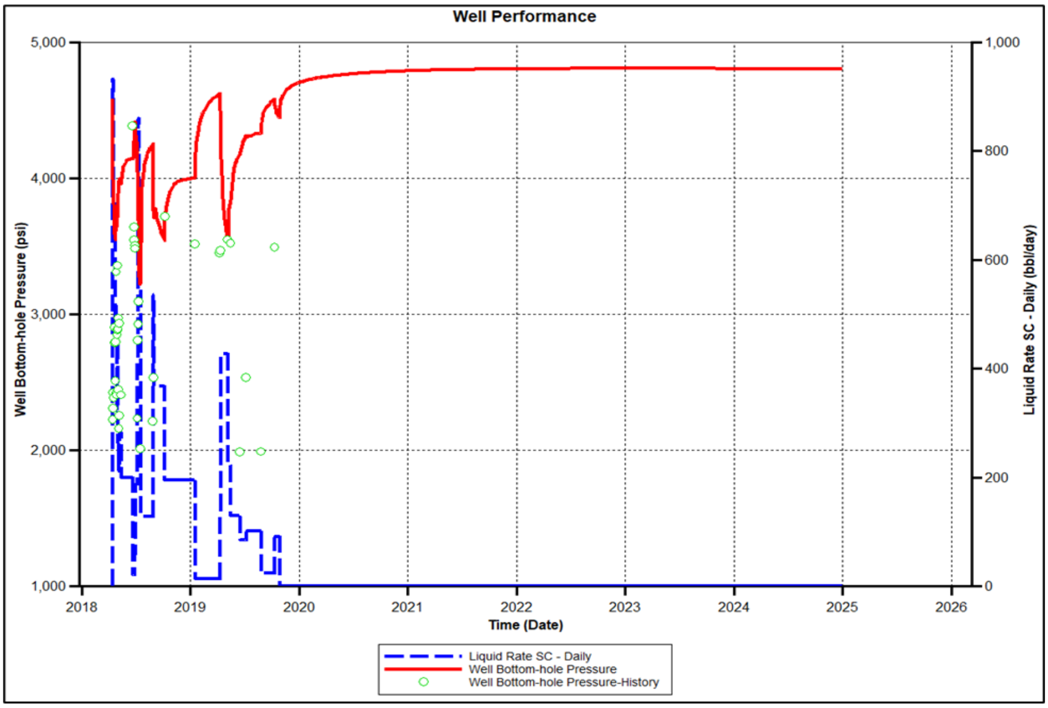


Fig. (3): Production Performance Scenario for Well (W-52)

There is a difference between the flow rate before and after implementing vertical hydraulic fracturing on 21-December-2016 as illustrated in Figure (4), in the second vertical hydraulic fracturing well (W-55), it cannot hold the different multi-suggested rates as horizontal hydraulic fracturing wells, and for this reason, the little contact area with the pay zone and the proppant exit during the production cause a reduction in fracture storage capacity. The first suggestion is to keep the oil rate at the last rate, as depicted in the green line, while the dashed green line shows a slight increase.

The second scenario suggested by trying to produce with the oil rate depicted in the yellow line above bubble point pressure depicted by the dashed yellow line shows it producing oil at a rate below 220 BOPD, and this rate is considered an uneconomic rate according to vertical hydraulic fracturing wells. We observed that most of the production period is below bubble point pressure. As a result, the only scenario that can be implemented is to maintain the same flow rate and flowing pressure below the bubble point pressure.

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

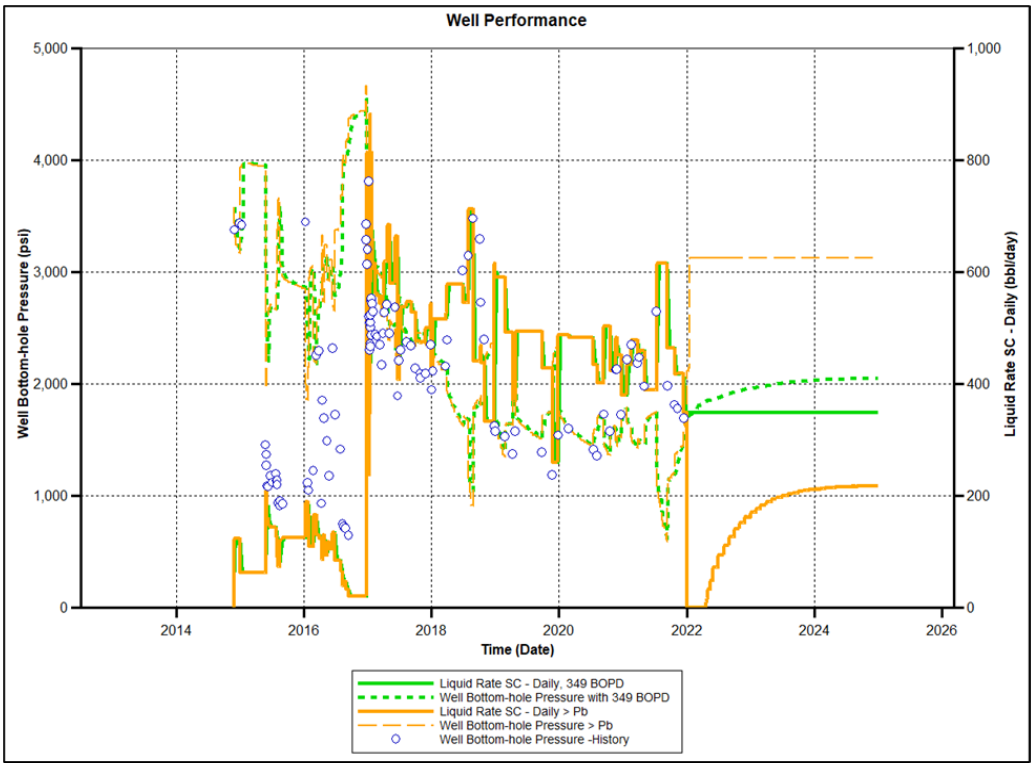


Fig. (4): Production Performance Scenarios for Well (W-55)

4. Conclusions:

Studying the behavior of hydraulic fracturing wells using simulator software in unconventional reservoirs for prolonging production as long as possible after they have suffered from a rapid decline in production and flowing pressure by identifying the final observation as follows:

1. Horizontal hydraulic fracturing wells produce a high oil rate at the beginning, then continuously decrease due to high liquid depletion from the fracture potential without enough liquid compensation from the reservoir into the fracture storage.
2. The optimal flow rate that will ensure stability until 2025 is determined for well (W-5) at 700 BOPD and well (W-6) at 900 BOPD.
3. The vertical hydraulic fracturing well in the tight formation started producing at high rates for a short period, then declined rapidly about 50% of the time it started producing. Most production periods are below bubble point pressure.

Lastly, if hydraulic fracturing wells started to produce, then following a novel approach to avoid the start of depletion, there are three keys to being considered:

a. Avoiding producing less than bubble point pressure.

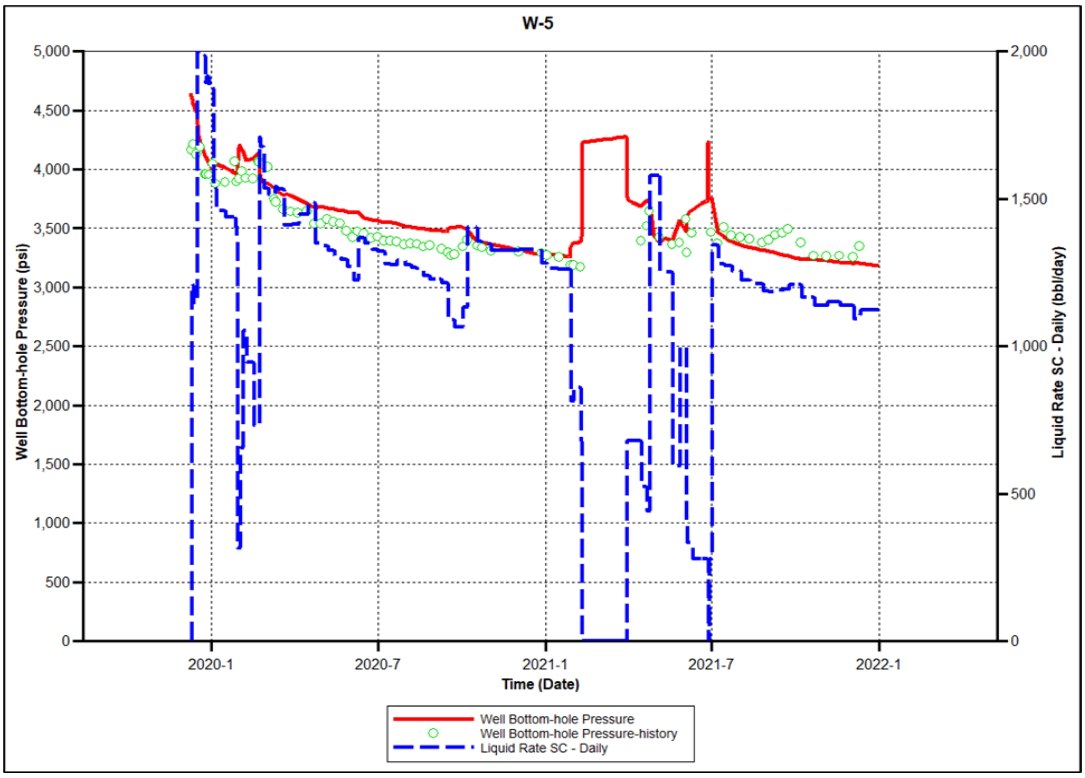
Journal of Petroleum Research and Studies

Open Access
No. 41, December 2023, pp. 66-77

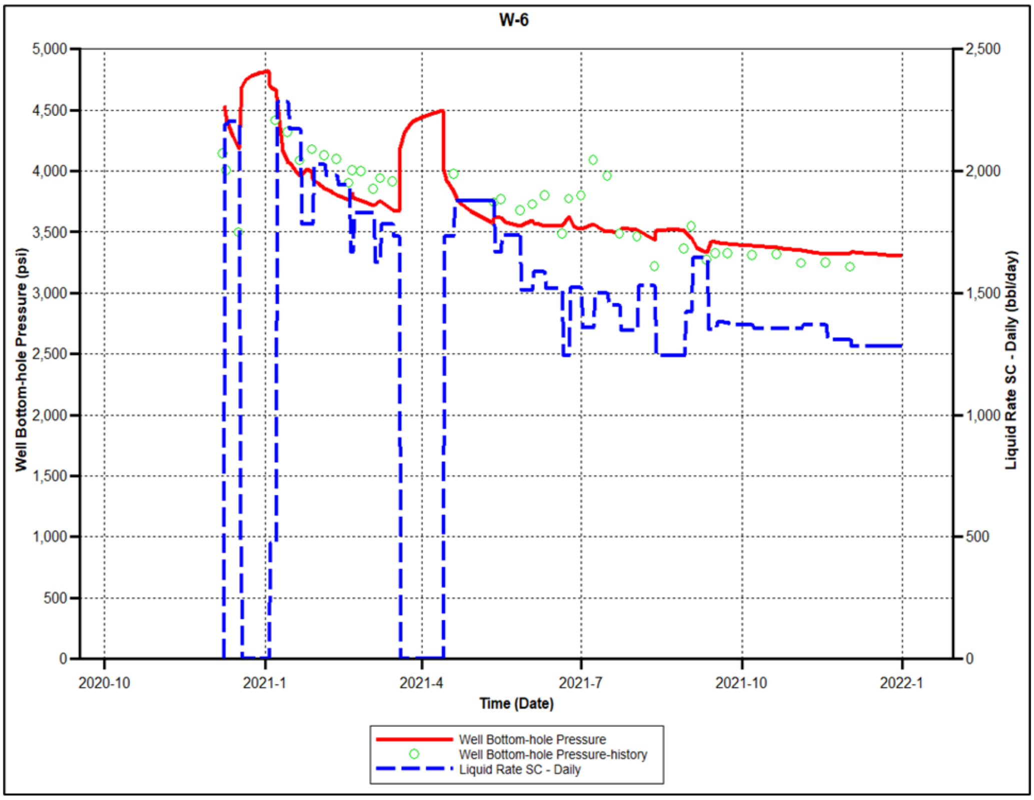
P- ISSN: 2220-5381
E- ISSN: 2710-1096

b. The primary control is tubing head pressure, which can be maintained by adjusting the choke size until it reaches a stable level or by increasing it while keeping the economical rate in mind.
c. Shut-in the hydraulic fracturing wells for enough time until the first shut-in tubing head can restore the original condition, then re-open the well with the following points: a and b.

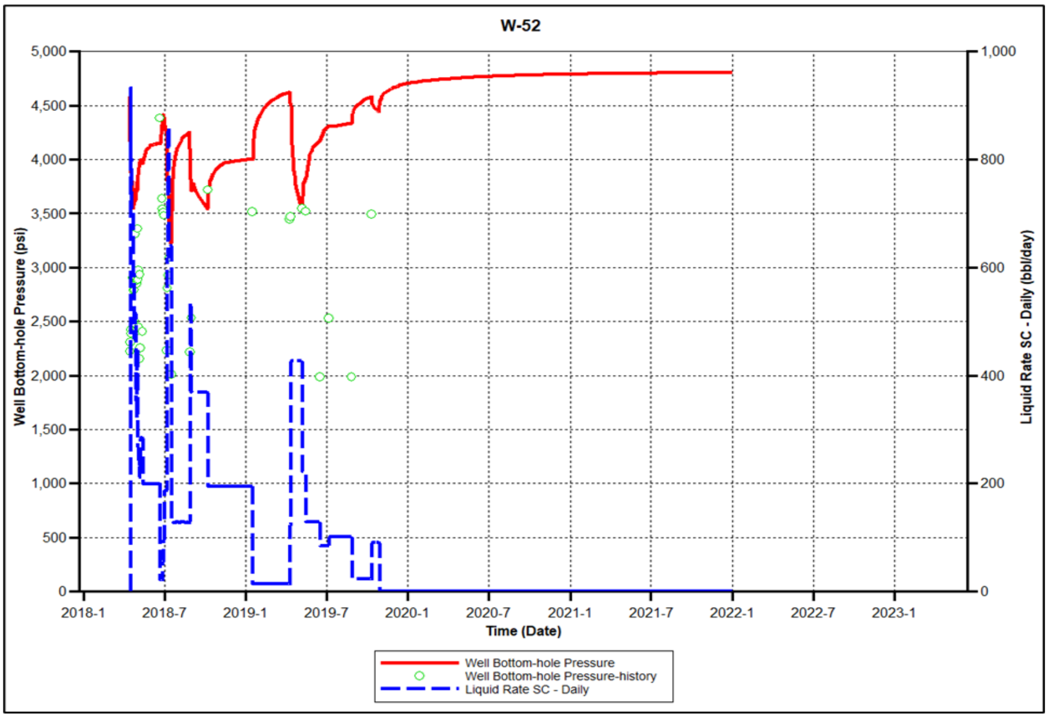
6. Appendices:



Appendix: (A) History matching of well (W-5)



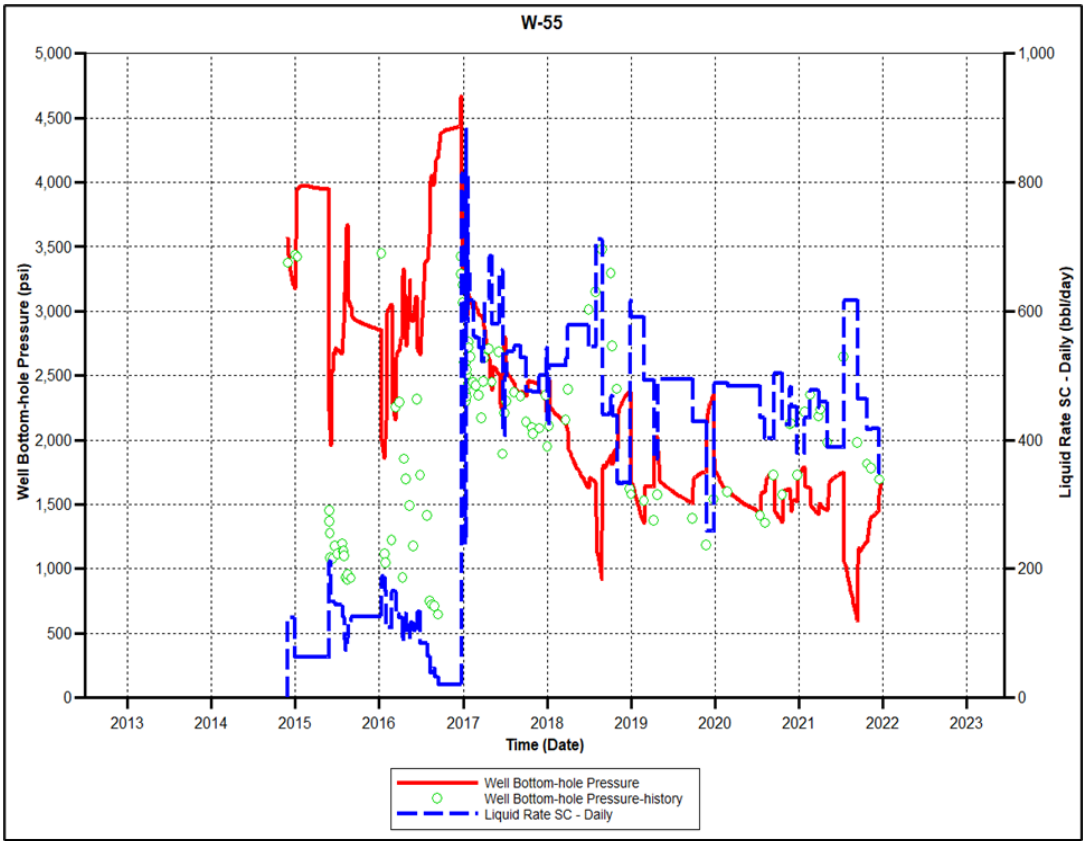
Appendix: (B) History matching of well (W-6)



Appendix: (C) History matching of well (W-52)

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096



Appendix: (D) History matching of well (W-55)

Open Access
No. 41, December 2023, pp. 66-77

P- ISSN: 2220-5381
E- ISSN: 2710-1096

References:

[1] M. S. Shahamat, S. Hamed Tabatabaie, L. Mattar, and E. Motamed, "Inflow performance relationship for unconventional reservoirs (transient IPR)", *Society of Petroleum Engineers - SPE/CSUR Unconventional Resources Conference*, no. 1936, 2015. https://doi.org/10.2118/175975-MS

[2] National Research Council, "Rock fractures and fluid flow: contemporary understanding and applications", National Academies Press, 1996.

[3] J. Guo, F. Gu, and J. Zhou, "Optimizing The Fracture Numbers and Predicting the Production Performance of Hydraulically Fractured Horizontal Wells", Paper presented at the Annual Technical Meeting, Calgary, Alberta, June 1997. https://doi.org/10.2118/97-108

[4] M. B. Issaka, M. W. Dahan, M. M. Al-Buraikan, and E. A. Verjan, "Real-time integrated field management at the desktop", Paper presented at the Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands, February 2008. https://doi.org/10.2118/112071-MS

[5] J. A. Al-Sudani and K. M. Husain, "Evaluation of Acid and Hydraulic Fracturing Treatment in Halfaya Oil Field-Sadi Formation", IJCPE, vol. 18, no. 4, pp. 25–33, Dec. 2017. https://doi.org/10.31699/IJCPE.2017.4.3

[6] Missan Oil Company, "Final well report", Missan, 2020.

[7] Petrochina, "Technical Support Team", 2012.