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Precisely Production Forecast After Conducting Hydraulic Fracturing Using Water Cut And Ratio Cumulative Production - Total Water Injected Trend

Mochamad Riza Zakaria*[1], Muhammad Soleh Ibrahim[2], Elrey Fernando B[3], Calvin Orliando[4], and Giyatno[5]
[1] PERTAMINA
* Email: Mochamad.zakaria@pertamina.com

Abstract. Alfa Structure was established at 1982 and performed 2 drilling wells. There is only one well that have been producing since 1982 to present with 30 bopd and cumulative 429 MSTB. This well produce with tank on site due to the distance with existing location. This structure has not been developed for a long time, therefore in 2019 a seismic 3D survey was conducted. Subsurface opportunity appearance from this study.

At least 7 wells plan were planned to be drilled to develop this structure. Main reservoir is Upper TAF with low resistivity and low quality reservoir therefore Hydraulic fracturing is a one of the proper methods to produce the well from Alfa Reservoir. More than 1000 bopd from 5 wells that has been drilled in 2021 and 2022 with using Hydraulic Fracturing method. Considering subsurface uncertainty to develop surface facilities, production forecast become essential especially in oil forecast. To monitor performance and forecast oil production after conducting Hydraulic Fracturing, this paper aims to share valuable field experience between Water Cut and comparation cumulative production - total water injected.

Alfa Structure produced only 30 bopd previously, but currently become more than 1000 bopd after developing 5 wells infill drilling with using hydraulic fracturing. Every Infill drilling that is carried out by hydraulic fracturing at the beginning of the start-up of well production, the fluid that comes out is water that we inject into the reservoir when doing hydraulic fracturing. Total water injected comes from Breakdown test, Multi rate test, calibration test and Main fracturing. By the time production, water will decrease and oil comes up with following Water Cut and comparation cumulative production - total water injected trend. As the result, The existence of this trend will be a reference in every monitoring of well production after using hydraulic fracturing and with that we can estimate more precisely when the well will produce according to its potential and very useful in surface facilities planning.

Keyword(s): Production Performance ; Water Cut ; Cumulative Production ; Low Quality Reservoir

Introduction

Field Overview

Alfa Structure is one of active structure in Limau Field, PT Pertamina Hulu Rokan, Indonesia (Fig 1). This structure was discovered by BPM in 1949 by drilling the well AF-01 and last development well was AF-11 in 1982. This Structure has 45 km^2 area with 11 wells that have been drilled, 3 producing wells in the west of the structure and only 1 producing well in the east of the structure. Oil Gathering Station Alfa is in the west area. The wells in the eastern area are wells AF-09 and AF-11. Well AF-09 had been produced since 1982 with 30 bopd until current production and has 429 MSTB oil cumulative production (Fig 2).

Besides that, well AF-11 had not been produced yet. The AF-09 is used production satellite due to economic and technical aspect. Oil transferred to Oil Gathering Station by truck.

Figure 1. Location of Limau Field

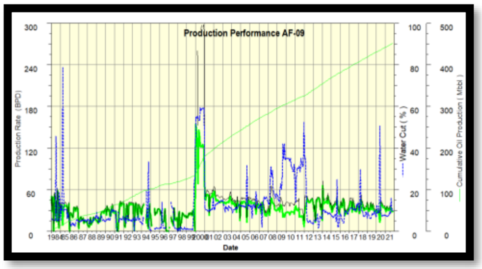


Figure 2. Production Performance AF-09

Acquisition data in 3D Model and Update Model Subsurface

In 2019, data acquisition in 3D model had been carried out in some structure of Field Limau with one of them is Alfa Structure with aims to see any potential again in this structure. While, previously in this structure, the subsurface model was made from seismic 2D only. The 3D survey covers a large area of 227 km^2 and because of that, several stages from 3D seismic are carried out (Fig. 3). This Alfa structure is divided into 2 area, eastern and western area. For Eastern area, the results of the 3D seismic study that had been carried out, shows that there are faults and depth structure of the maps had been changed from the previous version, thereby from that result, shows that in this structure still have more potential to be develop. Planning of Development (POD) report had been revised to aims proposed more infill wells in Eastern Area from this Alfa Structure, at least 10 infill wells are proposed to be drilled. While for Western Area will be developed again after 3D seismic have been carried out.

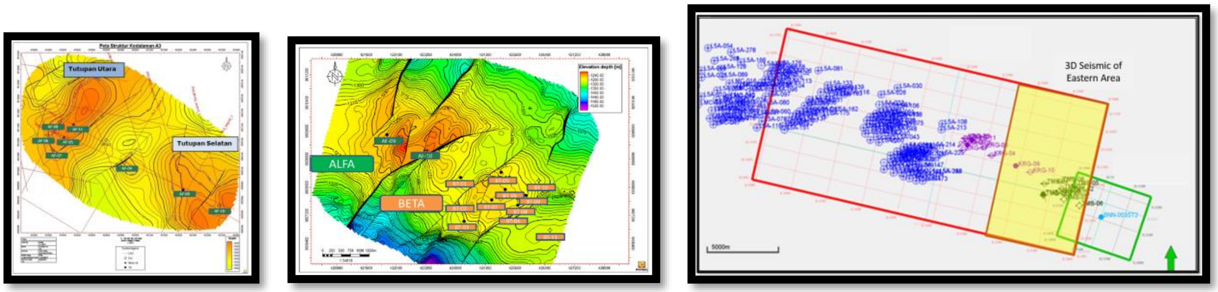


Figure 3. Map Area of Alfa Structure and Ground Map 3D Seismic of Eastern Area

Based on the existing 2 wells, it can be seen that the AF-09 well is not yet at the top of the structure so there is still the potential for adding absorption points to the top structure, as for the AF-10, which is already at the top of the structure, it still has the potential to add an absorption point to the flank. The determination of sealing faults in the Eastern Area of Alfa structure is seen clearly based on seismic interpretation and strengthened by pressure difference from the Reservoir layer in previous wells (AF-009 and AF-010). (Fig X1).

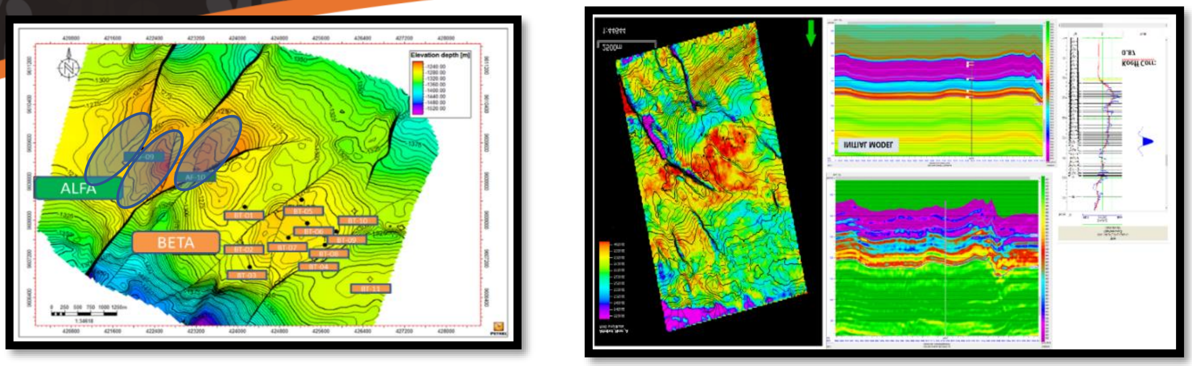


Figure 4. Eastern Area Pressure Cluster Difference and Result of 3D Seismic Volume Inversion

Development Alfa Structure of Eastern area.

In 2021, the first infill drilling was drilled after almost half a century of non-activity of drilling, because in this structure shown that there is no more potential to be developed and after 3D seismic had been executed, shown that is a lot area to be developed again in the Eastern Area of this structure. Currently for Eastern Area of this structure, there are already 3 wells were drilled in 2021 and 2 wells in 2022 by conducting hydraulic fracturing. We have planned to drill 5 more wells at 2023.

The Formation Reservoir in this structure is Upper TAF which is characterized by delta to sea sediments composed by a succession of sandstones and shale interspersed with coal and some of limestone. Generally, the sandstone is very fine to medium in size, argillaceous to calcareous (carbonaceous), with porosity and permeability that is poor to good. But this structure show that our permeability and porosity is very poor or low value (Low Quality Reservoir) and that why the development method that use in this structure is Hydraulic Fracturing.

From the Realization of Hydraulic Fracturing that had been carried out, it can be seen that production in area and reservoir of this area is show quite good production from only 30 bopd to more than 1100 bopd using Hydraulic Fracturing production wells in this eastern area (Figure 5).

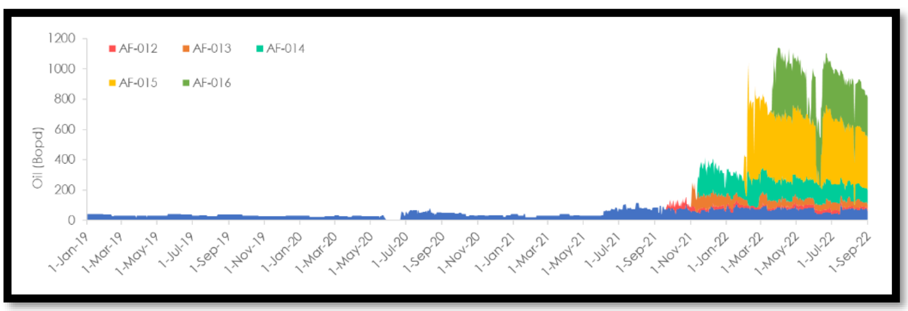


Figure 5. Production Profile East Alfa

The table below shows the formation parameter and fracturing design were performed in East Alpha. It shows that the hydraulic fracturing with 100 klbs minimum proppant volume in this structure is quite proper strategy to developed in this area and also developing this structure in the future.

Table. 1 Result of Realization Hydraulic Fracturing in Eastern Area

No	Well	K (mD)	Kh (mD-m)	Proppant Vol. (klbs)	Frac Length (m)	Frac Height (m)	Initial Gross (BLPD)	Initial Net (BOPD)	WC (%)
1	AF-12	4.9	96.67	79.14	67.9	29.8	173	105	39
2	AF-13	6.1	100.8	78.55	48.5	28.8	283	170	40

3	AF-14	3.2	190.66	97.81	95.56	33.3	344	330	4
4	AF-15	6.4	381.8	98.93	93.28	41.66	886	709	20
5	AF-16	2.77	166.3	100.6	108.25	35.64	551	440	20

Fracturing Operation Work Step

As we know that, Hydraulic fracturing is the process of injecting wells with water, sand, and chemicals at very high pressure. This process creates fractures in deeply buried rocks to allow for the extraction of oil and natural gas to be produced. In the Hydraulic Fracturing stage, the example on the AF-16 well can be seen as this follows below.

A. Diagnostic Test

In this Diagnostic test, there are 3 tests carried out, which is breakdown test, step rate test and mini Frac test.

<u>Break Down Pressure test</u>

Breakdown pressure also known as Injectivity test, is pumping liner fluid to get fracture gradient, Closure pressure, friction and formation transmissibility. In Well AF-16, fill up the well using 1.6 bbls 2% KCL Brine. Break Down Test was carried out by pumping 2% KCL 100 bbls brine at rate 8.2 bpm Surface pressure is around 2450 psi. Annulus pressure was kept at 300 – 500 psi. Hard shut-down, and found ISIP at 558 psi. (Fig 6)

<u>Step Rate Test</u>

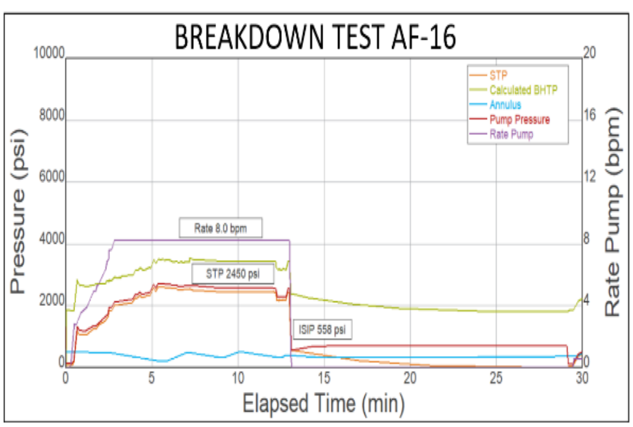
Step rate Test is a test performed in preparation for a hydraulic fracturing treatment in which an injection fluid is injected for a defined period in a series of increasing and decreasing pump rates. Step rate was performed to analyze dominant friction, fracture gradient and frac extension pressure. The Step Rate test in AF-16 was carried out with pumping rate varying from minimum achievable rate at 0.6 BPM to 18.0 BPM with 129.7 bbl total volume injected.

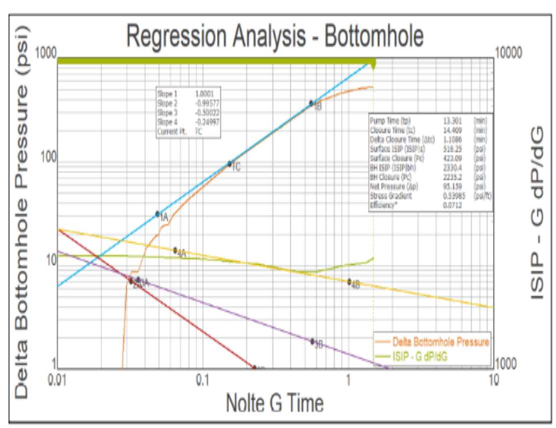
<u>Mini Frac test</u>

A minifrac test is a test with crosslinked fluid without proppant before a main fracture stimulation treatment. This test calibrate data which is performed in previous test because this fluid will be used in main fracturing. In AF-16 Well, the test pump 243.9 bbls crosslinked gel at 18.3 bpm.

B. Main Fracturing

All data in diagnostic test will be used to determined parameter in Main fracturing. Main Fracturing is the last step of the fracturing stage, crosslinked fluid pumped with 20/40 mesh proppant to the formation. In this case, 100.6 klbs and 1104 bbls crosslinked fluid ware pumped into formation.





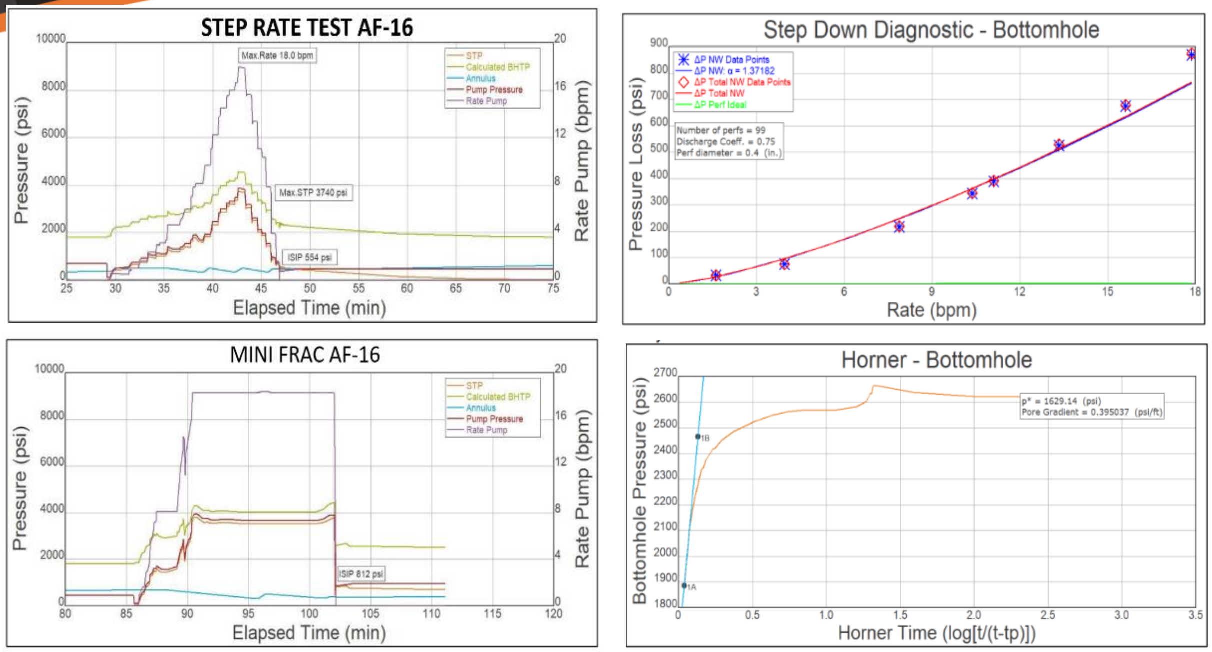


Figure 6. Result Graph of Diagnostic Test Hydraulic Fracturing AF-16

More than 1600 bbls water was injected to formation, it consist of 29.7 bbl string volume, 100 bbl in breakdown test, 129.7 bbl in step rate test, 249.3 bbl in minifract, and 1104.4 bbl in main fract.

The Relationship between Ratio Cumulative production/ Injection vs Water Cut with the Trend of Cumulative Production vs Water Cut

Basically, in Hydraulic Fracturing water comes first after conducting hydraulic fracturing. Water cut will be decrease until all water that have been injected comes out and will be replaced by formation water with following oil to be produced from reservoir. The test that is commonly used to distinguish between injected water and formation water is by measuring the Cl- content. Injection water will be higher due to using 2% KCl brine.

The concentration of KCl Brine is around 14000 - 15000 ppm while for formation water it is only about 8000-9000 ppm and if want to know the water produced is injected water it needs expensive costs and have to monitored every day.

This method can also see when and how much oil will be produced by looking at the water cut according to the plot between WC vs Prod/Inj and by looking and analyzing the results of existing data, it can be seen that the amount of water to be injected or the amount of proppant that will be use when executing Hydraulic Fracturing will not or does not affect the change in plot pattern between WC vs Prod/Inj and WC vs Cumulative Production. If the production data shows a change in the trend of the method that has been described, it is necessary to monitor the fracturing well which allows indications in the fracturing design error or when fracturing is executed.

Finally, after all the Hydraulic Fracturing processes or step had executed, it can be seen the production trend in the wells where it will be seen that the production trend between Cumulative Production vs Water Cut and the comparison trend of Cumulative Production / Injection vs Water Cut has the same trend which can be figure out in this below Figure 7.

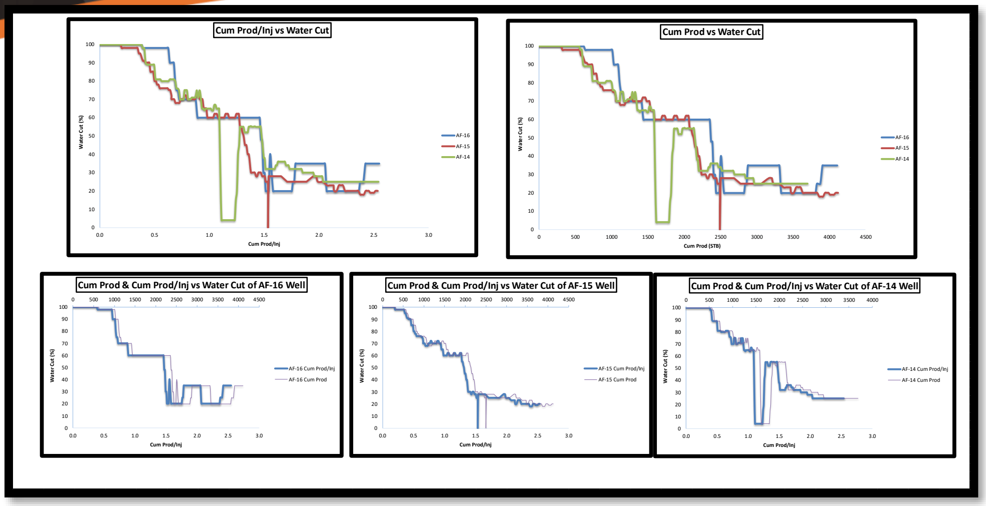


Figure 7. Plot Graph of Trend Cum Prod, Cum Prod/Inj and Water Cut of AF-14, AF-15 and AF-16

From the results of the chart above, it shows that the trend between cumulative production and the cumulative ratio of production/injection with the same value of Water cut is the same trend. So that, for example if there is a difference in the trend of increasing from the cumulative ratio trend, it shows that there is more water produced which could be from the failure of the hydraulic fracturing design when executed that penetrates the water zone from the fracturing results which can brings more water to produce or if the trend of cumulative ratio became smaller, it can indicate that there is water from the rest of the fracturing has not been produced so it needs treatment to overcome that problem.

Conclusion

Benefits and Conclusions :

1. From the three wells that had been fracturing, it proves that the result of trend between Cum. Prod and Cum Prod/Inj have the same trend when plotting against Water Cut with the same value.
2. For production wells that apply the Hydraulic Fracturing method, the successful of the design can be monitored through the trend between Cumulative Prod, Cumulative Prod / Inj Ratio and Water Cut. If the Trend between the two Cumulative is different then there is an indication of failure in the fracturing design. This method can also be one of the ways to predict the value of the existing water cut by looking at the clarity of the trend chart that has been described.
3. This method can also be one of the considerations for forecasting existing oil production judging from the cumulative production that has been recorded so that it will be one of the aspects in the construction of surface facilities in existing structures or fields.

References

1. Mahajan, M and Rauf, N. 2006. Water Control and Fracturing : A Reality. Paper SPE 101019. Presented at the 2006 SPE Asia Pacific Oil & Gas Conference and Exhibition held in Adelaide, Australia, 11-13 September 2006.
2. Amadi, Samuel U And Xie, Xueying. 2022. Understanding Water Cut Trends in Permian Basin Unconventional Reservoirs and Their Relationship to Development and Production Strategies. URTEC-3720245-MS. Presented at the SPE/AAPG Unconventional Resources Technology, Houston, Texas, USA,June 2022.
3. Jenkins, John And Wrightson. 2020. Identification and Remediation of High Water Cut Stages in Multi-Stage Hydraulically Fractured Wells : A Case Study in the Midale Formation. SPE-199984-MS. Presented at the SPE Canada Unconventional Resources Conference, Virtual, September 2020.
4. Hossain, Sabbir And Dehghanpour, Hassan. 2022. Port-Opening Falloff Test : A Complementary Test to Diagnostic Fracture Injection Test. SPE-209601-PA. doi:10.2118/209601-PA