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NEW BIOSURFACTANT METHOD IN STIMULATION TECHNOLOGY

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Abstract. Stimulation is a well intervention technology that injects special fluid to formation reservoir in order to change either fluid characteristics or reservoir properties. This special fluid is often chemical and in some cases microbes, which also known as bio-surfactant. After injecting microbes and nutrients to reservoir, microbes will produce bio-surfactant enzyme that encapsulates hydrocarbon. This event will cause oil drop to deform, split, and release from tight pores and then flow to wellbore. Unlike conventional bio-surfactant technology that uses actual microbes, a new approach was made in field Jambi by directly injecting bio-surfactant enzyme (the final product) into reservoir. The enzyme used is Bio-surfactant Enzyme for Recovery of Oil (BERO).

Candidates for BERO was chosen in AK structure layer 360. This layer has 19 ˚API and 50 cp viscosity. The fluid is heavy but not too severe. The problem was this layer also has sand problem, while BERO couldn't be executed in unconsolidated sand reservoir. Since this layer is promising to be stimulated, wells that has been performed sand control and succeeded in maintaining base sediment (BS) under 0.5% were chosen.

As a type of surfactant, BERO change wettability of rock surface from oil wet to water wet and reduce interfacial tension (IFT), thus higher production rate and recoverable factor. Conventional bio-surfactant method injects bacteria or microbes to reservoir that will produce bio enzyme. But this method would have big chance to fail if the microbes died. With BERO, bio-surfactant enzyme was directly injected into reservoir. First, laboratory test was performed on BERO. Compatibility test showed that BERO is compatible with AK brine with no precipitate was formed in the mixture. IFT test proved that with BERO 2% IFT can be reduced from 5.89 mN/m to 1.69 mN/m. Lastly, spontaneous imbibition test results in increase of recovery factor from 29.51% to 52.58 %. Based on this promising laboratory test, well AK-245 in AK Structure was chosen as pilot treatment.

By applying this surfactant well AK-245 get incremental production more than 50%. Before treatment this well had 24 BFPD /16 BOPD/31% last production test on December 10th 2019 and after treatment we got peak production of 33 BFPD/ 26 BOPD /20% and pump submergence increases from 6 m to as high as 148 m. Cumulative production after treatment is 2172 bbls from December 2019 until now. Production and fluid level survey show that this treatment applied successfully in well AK-245. Next chapter are to optimize the well and continue the treatment on other wells in AK structure.

Applying this new bio-surfactant method shows promising result that vouches its lab test and unlocks potential to continue treatment in other wells and structures.

Keyword: Bio-surfactant, Stimulation, Surfactant, Microbe, Wettability, Bio enzyme

1 Introduction

Layer 360 still has remaining reserves more than 1 MMSTB. Right now this layer contributes almost 29% of total production in AK Structure. All of wells that are producing from this layer have characteristics such as low influx, low water cut, high oil viscosity and sand problem. In order to solve the sand problem we have already performed sand control and succeeded. The idea to increase production of this layer is limited, we cannot do a fracturing job to increase the conductivity due to sand problem.

Surfactants are widely used to reduce IFT and significantly mobilize the entrapped oil (Hosseininoosheri et al, 2017), and it is suitable for AK Structure. Based on presented information above, stimulation with bio enzyme surfactant type that call Bio-surfactant Enzyme for Recovery of Oil (BERO) were applied. This surfactant is a polymeric biological enzyme and as a water-soluble product, it can efficiently release hydrocarbon on the surfaces of solid particles in reservoir. After being injected into the formation, due to activity, it can adhere to rock surface for a long time to change the property of rock formation into hydrophilic biological surface, reduce wetting angle and the interfacial tension of rock particles in reservoir, thereby reducing the flowing resistance of crude oil in reservoir pores; meanwhile, due to biological degradation effect, this biosurfactant will continuously deform and split oil drops until oil drops are released from rock formation, thus not only being able to loosen the crude oil of retention layer, but also making oil drops become smaller and more easily exude through the pores of rock formation until they are recovered. thereby achieving the effect of cleaning cause of tis surfactant quickly peel off the crystal substances, paraffin, asphaltenes on the rock particles after injected into the reservoir. With that cleaning effect of this surfactant will increase the conductivity so our goal can be achieve. Meanwhile, it will not produce other new product, so it will not plug pores or cause secondary pollution. Reaction process of BERO is shown in Figure 1.

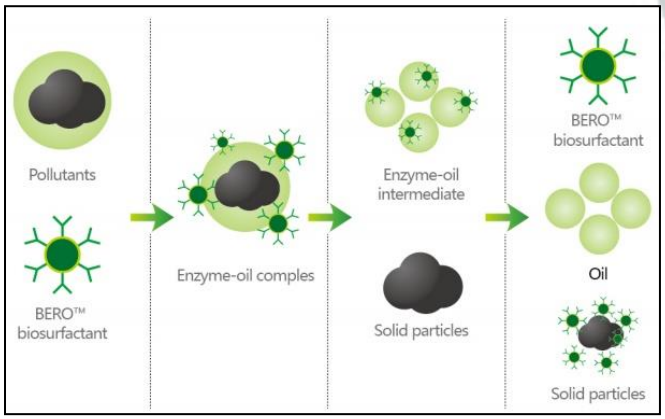

Figure 1 Reaction Process of BERO

In this application, BERO is functioned as Acid that could remove inorganic plugging and ultimately increase production.

2 Bio-surfactant Enzyme for Recovery of Oil (BERO)

There are some advantages in using bio-surfactant instead of conventional surfactant (Fakruddin, 2012):

1. Biodegradability: Biological surfactants are easily degraded by microorganism (Mohan et al, 2006)
2. Availability of raw materials: Bio-surfactants can be produced from very cheap raw materials which are available in large quantities. The carbon source may come from hydrocarbons, carbohydrates and /or lipids, which may be used separately or in combination with each other (Kosaric, 2001)
3. Physical factors: Many bio-surfactants are not affected by environmental factors such as temperature, pH and ionic strength tolerances.
4. Surface and interface activity: Mulligan (stated that a good surfactant can lower surface tension of water

Based on this advantages, it shows that bio-surfactant is more environmentally friendly than conventional surfactant while main purpose of surfactant, which is reducing IFT, is still maintained.

The conventional bio-surfactant method injects bacteria or microbes to reservoir that will produce bio enzyme but would have big chance to fail if microbes died. But with this new method we directly inject bio-surfactant enzyme into reservoir. The reaction of BERO is biological reaction; it's different than the effects of chemical and bacterial. It will be directly effective to the pollutants, but it won't change the characters of the crude oil.

Implementing BERO into reservoir will have benefits as follow:

1. Increase oil mobility
2. Improve oil displacement
3. Create biofilm on the rock surface
4. IFT reduction at 10^-1mN/m
5. Remove plugged reservoir result from paraffinic wax and asphaltene precipitation
6. Oil well tubular column cleaning (during work over job)

Figure 2 shows how BERO works.

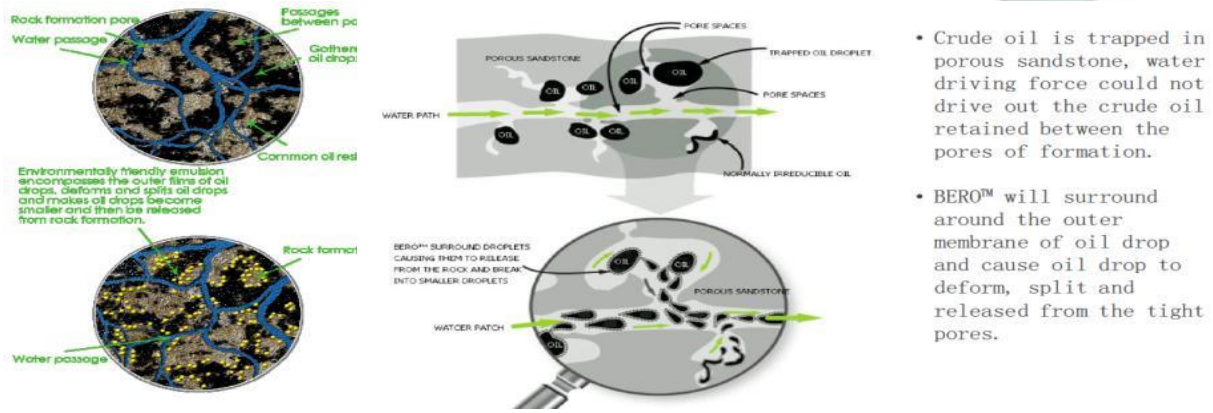

Figure 2 How BERO works

The first step that was performed was screening wells that meets criteria for BERO treatment. Also we also chose wells that has been successfully treated with sand control job. Below are the criteria for BERO treatment.

1. Sandstone Formation priority, then the limestone and other carbonate rocks
2. Porosity >10 %, Recommended: Porosity > 20%
3. Acidity is allowed Ph 4-7
4. Temperature formation between 50 ^{0} F < 180 ^{0} F
5. Permeability allowed ≥ 10 mD
6. Pressure formation >150 Psi
7. Viscosity oil in Reservoir < 200 cP
8. Water Cut between 20 % - 85 %
9. Light and Intermediate Oil
10. Reservoir Thickness greater than 10 ft

BERO is not applicable to these conditions:

1. Heavy Oil (Viscosity >150 cP)
2. Reservoir is sensitive of water
3. Not applicable for Gas wells
4. Not applicable for reservoir with sand problem

Figure 3 shows fluid characteristics for layers in Field Jambi, with green bar is oil API and yellow bar is oil viscosity.

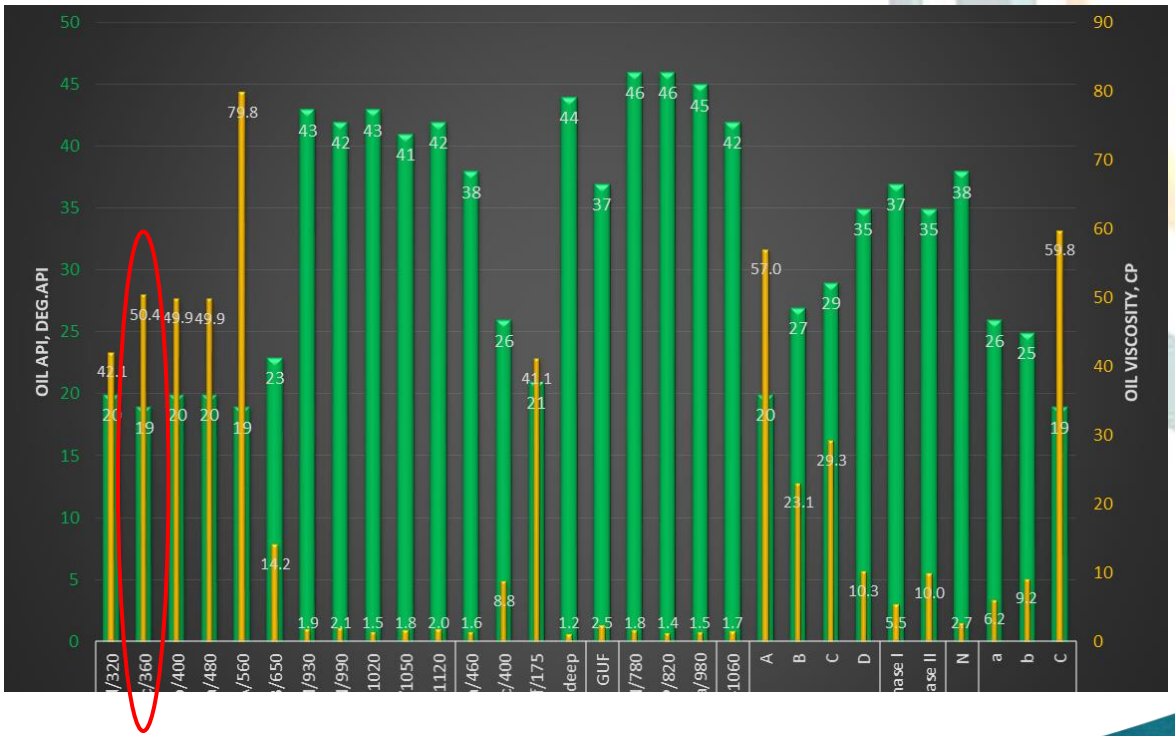

Figure 3 Screening process for BERO

It can be inferred in Figure 3 that reservoir with quite heavy oil are Layer 320, 360, 400, 480, and 560 in AK Structure. Even though these layers contain heavy oil, but they are still in range of acceptable criteria for BERO treatment. Layer 360 was chosen because it has quite some wells that produced from that layer itself. Most of wells in AK structure were produced from more than one reservoir. Well AK-245 was chosen to be candidate for BERO stimulation. Figure 4 shows Well AK-245 production performance. From this production chart 16 bopd was chosen as production baseline to evaluate stimulation result afterwards.

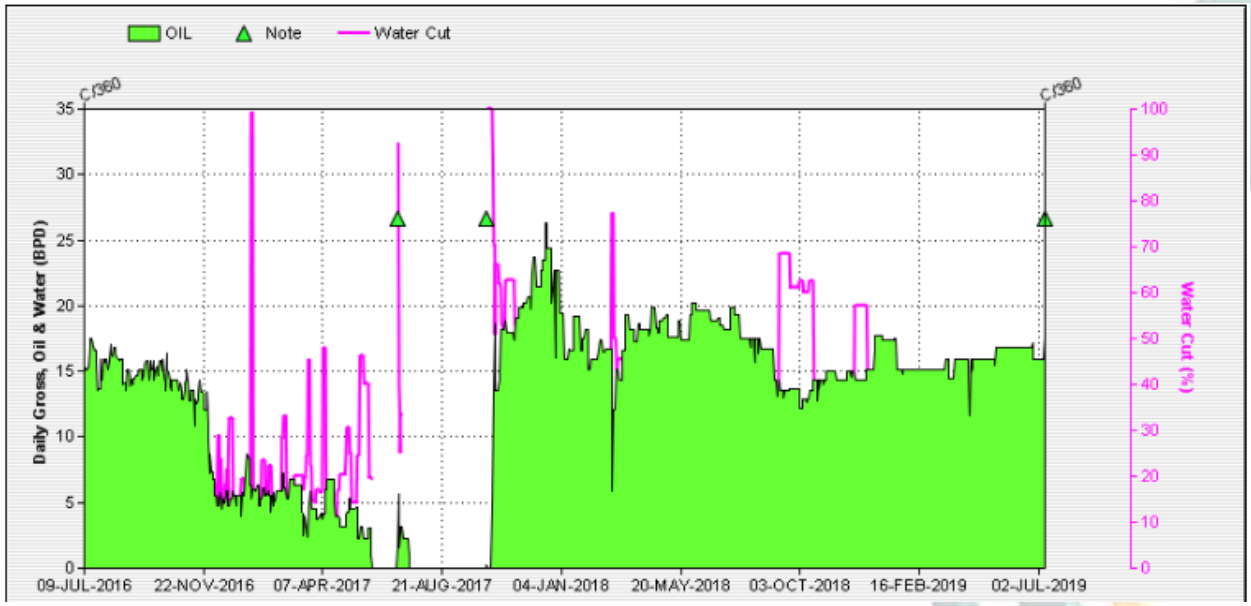

Figure 4 AK-245 production performance

3 Result and Discussion

3.1 BERO Laboratory Test

Before execution laboratory test was performed on BERO and fluid from AK structure (brine and crude oil). Scope for the test are as follow:

- Determine the compatibility of the brine injection and BERO Bio-Surfactant
- Analyze the performance of BERO Bio-Surfactant to improve oil recovery factor
- Understanding the mechanism of BERO Bio-Surfactant in improving oil recovery in the AK Structure

Since there is no core sample from AK Structure, Berea cores with different permeability and porosity were used instead.

3.1.1 Compatibility test

Objective of this test was to determine the compatibility of the brine and BERO Bio-Surfactant. Observation was conducted in room temperature (25 °C) and reservoir temperature (60 °C) for 1 week. Result of the observation:

- The solution is clear
- No suspended solid
- No sediment

It means that BERO is compatible with fluid from AK Structure. Figure 5 shows compatibility test result.

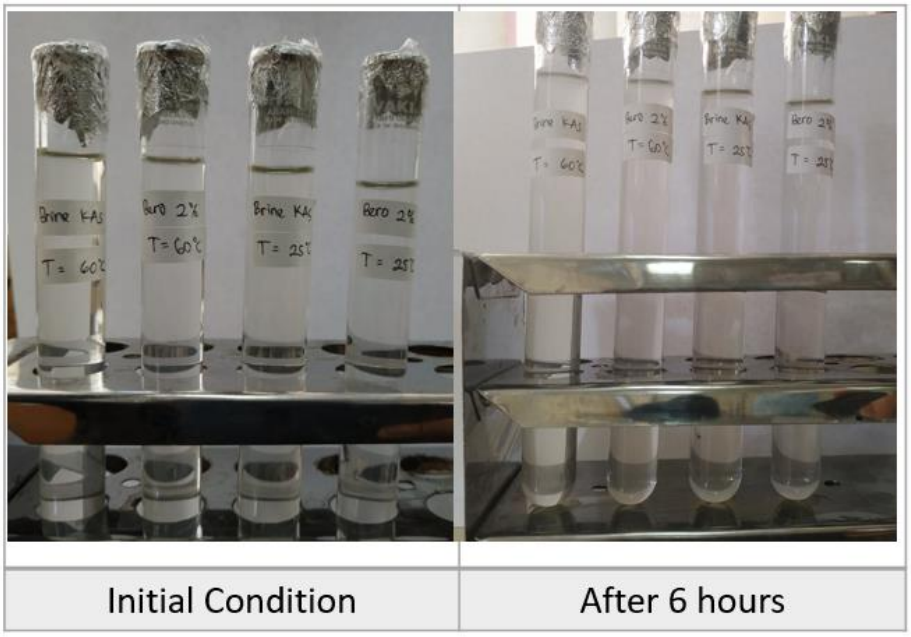

Figure 5 Compatibility test result

3.1.2 IFT test

Objective of this test was to calculate the interfacial tension between solution and oil. Observation shows that there is a decrease in number after BERO enter the experiment. The lowest IFT number was when BERO 2% solution was used. Table 1 and Figure 6 shows IFT test result.

No.	Nama	Minyak	FT (mN/m)	Keterangan
1	Brine KAS WIP	Oil AK	5.8902	Stable, intact
2	1% Bero BioSurfactant	Oil AK	1.7966	Stable, Intact
3	2% Bero BioSurfactant	Oil AK	1.698	Stable, Intact
4	3% Bero BioSurfactant	Oil AK	1.8482	Stable, Intact

Table 1 IFT lab test result

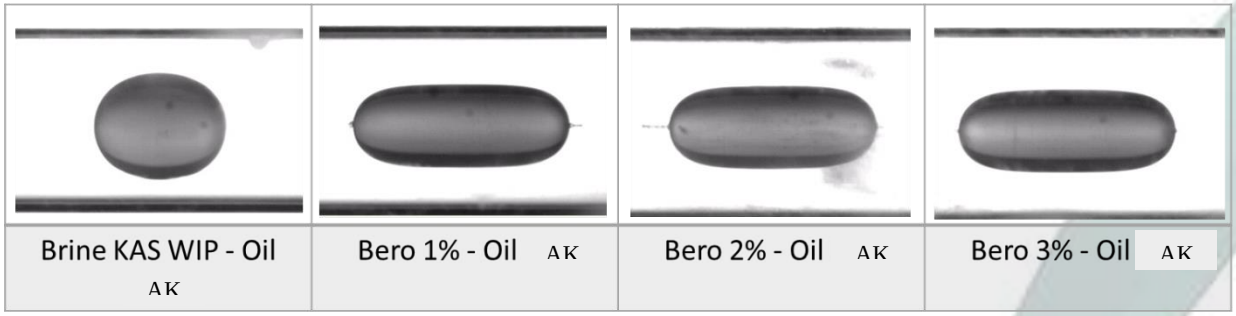

Figure 6 IFT lab test result

3.1.3 Imbibition test

Objective of this test was to analyze the performance of solution in increasing oil recovery in Huff and Puff method. As previously stated Berea cores were used for this test. Figure 7 shows its result.

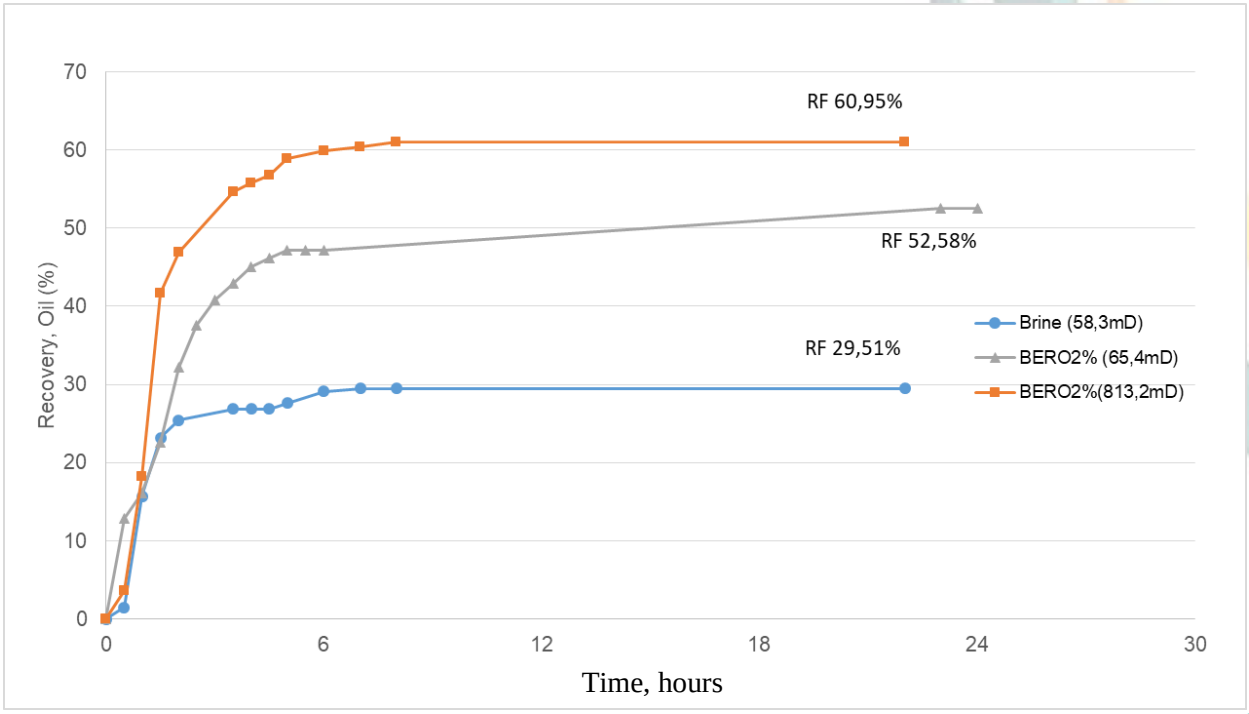

Figure 7 Imbibition test result

From imbibition test, it can be inferred that injecting BERO will result in an increase of recovery factor (RF).

3.2 BERO Execution and Result

BERO stimulation steps show in Figure 8. This job uses huff and puff method with soaking for 5-7 days after injection.

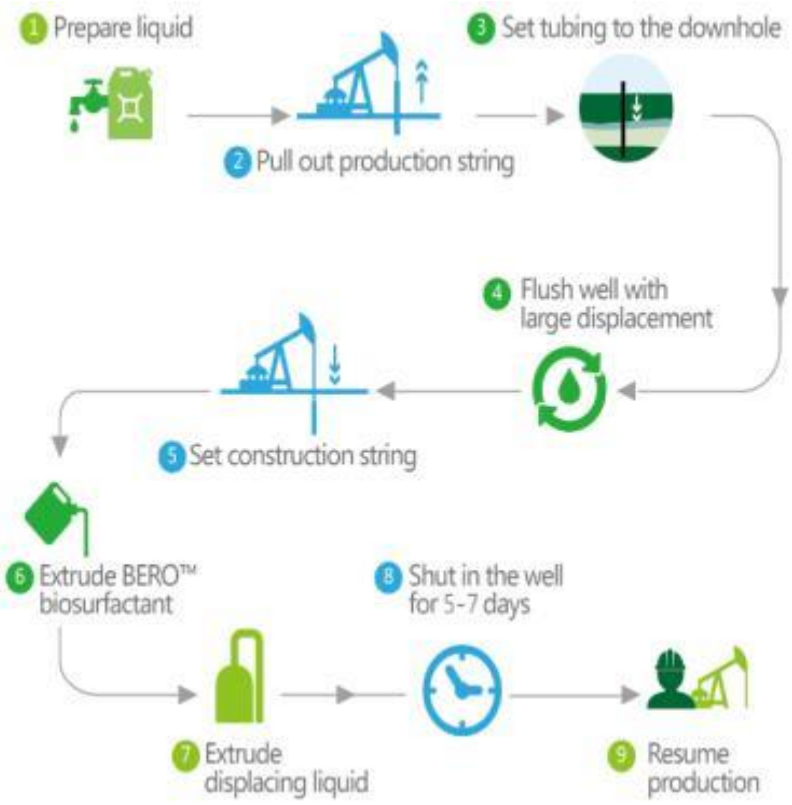

Figure 8 BERO job procedures

Stimulation job was performed on December 25th, 2020 with pump chart shown in Figure 9 and calculation in Table 2-4.

Depth of Penetration in Radial Flow		
Perforated Zone Interval	7	meter
	23	feet
Porosity	20.0	%
Depth Penetration	10.1	ft
Injection Volume	11000	gal
Treatment	479	gal/ft
Predicted Effective Penetration	8.59	ft

Table 2 Treatment volume design

TREATMENT	VOLUME		
	Gals / ft	Gallon	Bbl
Huff and Puff Treatment Volume	478.9	11000	261.90
Displacement Volume	Tubing	465	11.08
	Casing	1634	38.91

Table 3 Treatment volume calculation

Stage	Rate (BPM)	Tubing Press (PSI)	Total Volume (Bbl)
Surfactant	1.2	565	261
Displaced	1.2	574	11

Table 3 Treatment pump design

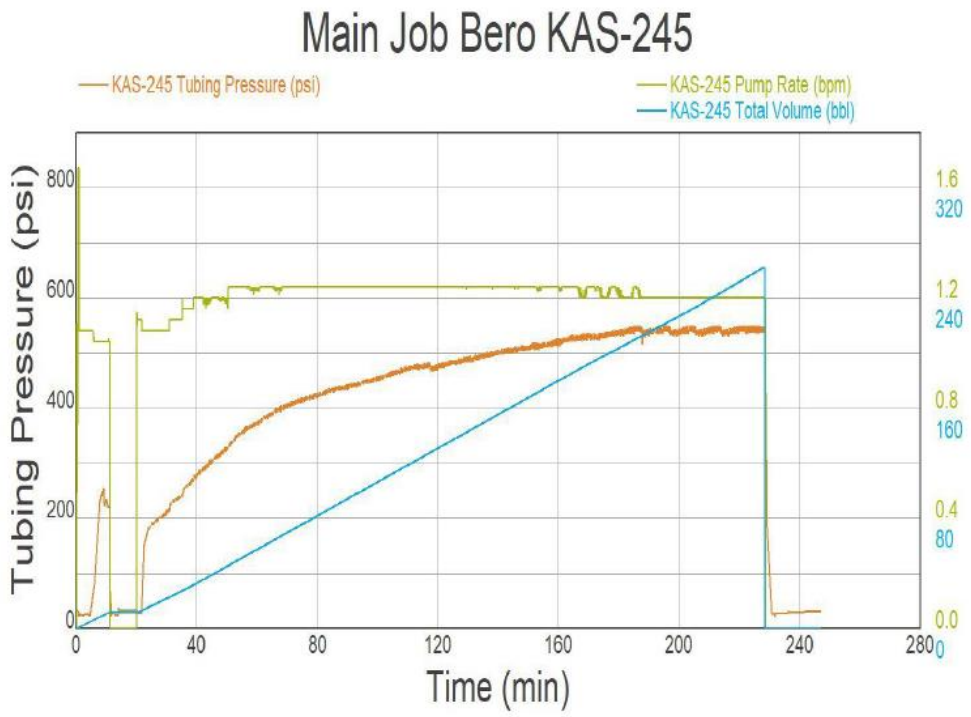

Figure 9 Treatment pump chart

From operation stand point job was performed smoothly. After soaking for 7 days, well AK-45 was then produced. Figure 10 shows production performance after treatment.

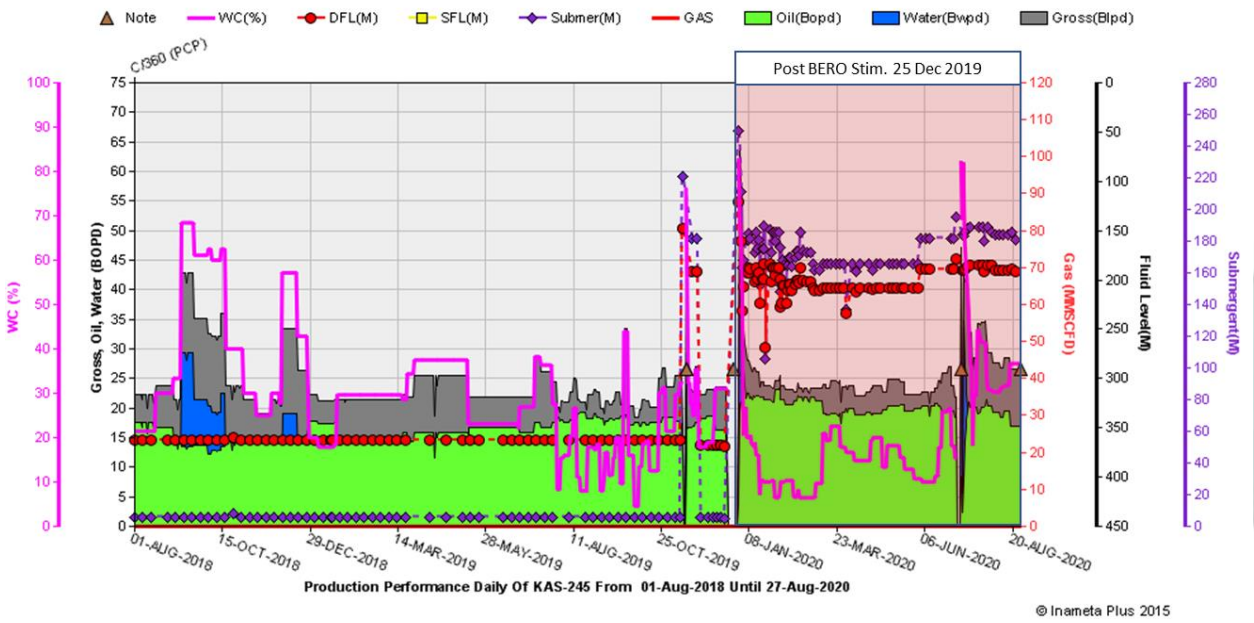

Figure 10 AK-245 production performance

It can be inferred from Figure 10 that this treatment shows promising result with incremental production more than 50%. Before treatment this well had 24 BFPD /16 BOPD/31% last production test on December 10th 2019 and after treatment we got peak production of 33 BFPD/ 26 BOPD /20%. Another sign of success was that we got increase in fluid level/submergence. Therefore, after treatment, door for well optimization was opened.

4 Conclusion

BERO stimulation was successfully performed in KAS-245 with peak production of 33 BFPD/ 26 BOPD /20%. There was also a significant increase in fluid level/submergence that open door for production optimization of this well. Next step to do is to perform production optimization in Well AK-245 and perform stimulation in other well candidates to further evaluate BERO effectiveness in increasing oil production.

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