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Laboratory Study of Analysis of the Effect of ABS Surfactant Injection on Increasing Oil Recovery

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ABSTRACT: The decline in oil recovery in oil and gas fields is a problem that must be faced now and in the future along with the increasing need for petroleum energy. Increasing oil recovery reserves requires an advanced method, namely Enhanced Oil Recovery (EOR). Surfactants are one of the enhanced oil recovery (EOR) methods to increase oil recovery. This laboratory research will use a surfactant solution, namely ABS Surfactant (Alkyl Benzene Sulfonate). There are five concentrations for each surfactant, namely 0.3; 0.5; 0.75; 0.9; and 1% with the same salinity of 7,000 ppm. In this study, ABS surfactant was used because the surfactant has the characteristic of being able to reduce interfacial tension. This research carried out a phase behavior test to determine the stability of the emulsion with a measurement time of 7 days at a temperature of 80 °C. Making an ABS surfactant solution, 70% ABS fluid is available where the surfactant raw material will be mixed with brine with a salinity of 7,000 ppm. There are several stages carried out, namely density test, phase behavior, interfacial tension, and core flooding. After making a sample of the ABS surfactant solution, the second step was to carry out a density test using a DMA-4100 densitometer to determine the density of the ABS surfactant solution at temperatures of 30 °C and 80 °C. The third is a phase behavior test where the surfactant solution will be mixed with oil and then placed in an oven at a temperature of 80 °C for 336 hours to obtain emulsion results that are close to the midpoint so that the stability of the emulsion is more optimal. The fourth is to determine the IFT value with a surfactant sample that has the highest volume of microemulsion stability. Finally, the core flooding test is to determine how much oil is recovered from the sandstone when surfactant injection is carried out. In the IFT results, the ABS surfactant solution was able to reduce the interfacial tension well between oil and formation water in the reservoir, where the interfacial tension value was 0.0055654 dyne/cm. The results of core flooding with ABS surfactant with a concentration of 0.9% salinity of 7,000 ppm obtained a recovery factor of 14.545%.

KEYWORDS: Alkyl Benzene Sulfonate, Interfacial Tension, Phase Behaviour, Surfactant, Sandstone.

INTRODUCTION

The decline in oil recovery in oil and gas fields is a problem that must be faced now and in the future along with the increasing need for petroleum energy. Increasing oil recovery reserves requires an advanced method, namely Enhanced Oil Recovery (EOR). EOR is a method that can be used to increase the amount of hydrocarbons that can be obtained from a field after the primary and secondary stages of production have been completed (Massarweh and Abushaikha 2020). There are various EOR methods consisting of chemical injection, gas injection, thermal injection, and microbial injection. Sweeping efficiency can be increased by reducing the oil-water mobility ratio which is influenced by fingering(Kargozarfard, Riazi, and Ayatollahi 2019). Chemical injection, which can be alkaline, surfactant, or polymer. The EOR stage is carried out after the end of the water injection process, if the amount of oil remaining in the reservoir is still quite large (Pauhesti, Kasmungin, and Hartono 2018).

Surfactants are one of the enhanced oil recovery (EOR) methods to increase the recovery of oil and surfactants, including the most commonly found chemical injection methods. This can reduce the interfacial tension between oil and water so that it can sweep oil away from rocks that are oil wet rock (Green, D W 1998) The properties of surfactants are that they can reduce surface tension, interfacial tension, increase the stability of the dispersed particles and control the type of formulation, either oil in water (o/w) or water in oil (w/o) (Schramm, Stasiuk, and Marangoni 2003). The addition of surfactants in a solution will cause a decrease in the surface tension of a liquid solution and the phase interface, both liquid-gas and liquid-liquid (Anastasia Wulan Pratidina Swasono, Putri Dei Elvarosa Sianturi, and Zuhrina Masyithah 2012)

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The physical properties of ABS surfactant such as viscosity and density were measured using the 'Redwood' viscosity method and pycnometer. The physical properties of activated carbon for calculating the minimum fluidization rate such as measuring activated carbon porosity are carried out by measuring the remaining empty space (cavity volume, M3) in packed activated carbon(Sablayrolles et al. 2009). Alkylbenzene Sulfonate (ABS) is starting to be used by manufacturers as a substitute for Branch Alkyl Benzene (BAB) because it is considered more environmentally friendly and easily broken down by microorganisms (biodegradable). Alkylbenzene Sulfonate (ABS) is an anionic surfactant in liquid form with the molecular formula C12H25C6H4SO3Na which is used as a raw material in the detergent industry, apart from that ABS is also used as a material to reduce surface tension or interfacial tension in industry (Deby Febrianty Isba Diputri 2021).

The research was carried out on a laboratory scale with the aim of determining the density and specific gravity obtained with changes in temperature of 30 °C and 80 °C in brine, crude oil, and ABS surfactant. From the physical test process, it was found that the higher the concentration of the food solution, the values of density, viscosity, and specific gravity would also increase (Nugraha et al. 2022a, 2022b). To determine the nature of the interfacial tension of ABS surfactant on Crude Oil, before carrying out the IFT test, first carry out a phase behavior test to determine the appropriate salinity and type of emulsion that can be mixed with crude oil to reduce the interfacial tension or to studied the behavior of hydrocarbon mixtures, salinity, and surfactant systems at cold temperatures(Gao and Sharma 2013). Several opinions state that this behavior test is a faster test stage and makes it easier to determine the IFT value and the effectiveness of the performance of the surfactant solution being tested(Dian Farkhatus Solikha 2021). Good results in this phase behavior test are that surfactants with a certain concentration and salinity form a middle-phase emulsion (Riswati et al. 2020) In this case, the mid-phase emulsion is one of the main mechanisms that shows the success of EOR using surfactants other than oil-surfactant IFT values of less than 10 mN/m; reducing the IFT of oil and other fluids and controlling wettability in rock pores (Marques and Silva 2013).

Surfactant injection is widely used in EOR techniques because the application technique is relatively simple and the recovery obtained is relatively large compared to conventional water injection. The mechanism for increasing recovery with surfactants reduces interfacial tension, reduces the mobility of the pressing fluid, and communicates with a wider reservoir volume limit. The increase in surfactant concentration to form micelles is called higher critical micelle concentration (CMC) to achieve the desired mobility control(Arina and Kasmungin 2018). The working mechanism of surfactants in reducing interfacial tension, the hydrophilic part (likes water) will enter a polar solution and the lipophilic part (likes oil) will enter a non-polar solution so that the surfactant will combine two compounds that cannot actually combine (Anggie Suci Meilanie 2021).

Apart from that, this research uses sandstone rock samples as reservoir media. Reservoir rocks are permeable rocks, namely porous rocks where the pores are interconnected so that they can pass fluids with different densities and viscosities (Peters 2012).

METHOD

The research was carried out in the enhanced oil recovery (EOR) laboratory, Faculty of Earth and Energy Technology (FTKE), Trisakti University. The research work steps carried out in this laboratory included preparation for making synthetic formation water, making surfactant solutions, measuring the physical properties of the solution, measuring stress. interface and ABS surfactant injection. The materials used in this research were ABS (Alkyl Benzene Sulfanoate) surfactant solution with a concentration of 0.3; 0.5; 0.75; 0.9 and; 1% with a salinity of 7,000 ppm, crude oil with an API of 41°API.

The series of preparations and experiments carried out in this laboratory began with making a solution, namely brine and surfactant, then testing the physical properties of the solution, namely density at temperatures of 30 °C and 80 °C, then interfacial tension at a temperature of 80 °C. After that, the most optimum solution was selected, measurements were carried out at a concentration of 0.3; 0.5; 0.75; 0.9, and 1%. The next step is to test the Interfacial Tension value using the Spinning Drop Tensiometer Series 500D which is based on the balance of centrifugal force and interfacial tension (Gao and Sharma 2013). To get the CMC or Critical Micellar Concentration point, where to find the lowest and most economical interfacial tension point.

The salinity of the formation water used in this research is 7,000 ppm, so as not to reduce the ability of surfactants to increase oil recovery from the model, it is made by dissolving 7 grams of NaCl in 1000 ml of distilled water which will be stirred with a magnetic stirrer. The oil used in this research is light oil with an API value of 41°API.

Fluid density and specific gravity are measured using a tool called a Density meter. Meanwhile, measuring the interface tension uses a Spinning Drop Tensiometer Series 500D. To test ABS surfactant injection into sandstone rocks using a Core holder.

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CONCLUSION

There are several research stages and their results, namely making a surfactant solution, density test of the surfactant solution, phase behavior test, interfacial tension test of the surfactant solution, measuring sandstone cores, and core flooding testing. These seven things have reliable results because this research is primary data that is directly examined objectively in the laboratory.

Density Test

Density or density testing uses a tool called the Densitometer DM-4100. Where testing using a densitometer includes the density and Specific Gravity of a surfactant solution, brine, and Crude Oil. The results of density testing can be seen in table 1 regarding the density and specific gravity of crude oil and brine.

Table 1. Density and Specific Gravity Crude oil and Brine

Sample name	Temperature (deg C)	API	Densitas (gr/cc)	SG
Rantau *crude oil*	30	41,3561	0,816	0,8186
	80	45,2424	0,7786	0,8006
Brine 7.000 ppm	30	-	1,0001	1,0044
	80	-	0,9687	0,9968
Aquadest	30	10	1	1

Next, testing the ABS surfactant using a Densitometer can determine the density and Specific Gravity. Carried out first at a temperature of 30 °C after completion, then changed to a temperature of 80 °C. This takes a long time because the temperature of 80 °C takes time to rise due to the gradual increase in temperature on the densitometer, if it is not done properly there will be an error in the reading of the instrument.

Table 2. ABS Surfactant Density and Specific Gravity

Surfactant sample	Surfactant concentration (%)	Temperature (°C)	Density (gr/cc)	SG
ABS 1	0,3	30	1,0001	1,0042
		80	0,9515	0,9792
ABS 2	0,5	30	1,0012	1,0044
		80	0,9740	1,0028
ABS 3	0,75	30	1,0015	1,0044
		80	0,9745	1,0026
ABS 4	0,9	30	1,0015	1,0045
		80	0,9748	1,0031
ABS 5	1	30	1,0017	1,0045
		80	0,9758	1,0042

Phase Behaviour

The phase behavior test was carried out on field X oil samples with ABS surfactant and AOS surfactant, where this test used a 4 ml tube for seven days and was heated to a temperature of 80 °C in an oven. The crude oil phase behavior test with ABS surfactant (0.3; 0.5; 0.75; 0.9; 1%) was carried out at a temperature of 80°C and a salinity of 7000 ppm.

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Table 3. ABS phase behavior test results

Oil	ABS Surfactant Composition	Phase	Volume at Observation Time (hours) 2	24	48	168	336	Total emulsion (%)	Types of Phase Emulsions
X 45,24 °API	Salinity 7000 ppm 0,3 %	Oil	2	2	2	2	2	0,00%	None
		Emulsion	0	0	0	0	0		
		Surfactant	2	2	2	2	2		
	Salinity 7000 ppm 0,5 %	Oil	1,9	1,9	1,95	1,96	2	0,00%	none
		Emulsion	0,05	0,05	0,02	0,01	0		
		Surfactant	2,05	2,05	2,03	2,03	2		
	Salinity 7000 ppm 0,75 %	Oil	0,3	1,47	1,85	1,9	1,9	1,25%	Upper phase
		Emulsion	2,12	0,58	0,12	0,05	0,05		
		Surfactant	1,58	1,95	2,03	2,05	2,05		
	Salinity 7000 ppm 0,9 %	Oil	0,14	0,98	1,2	1,94	1,94	2,50%	Middle phase
		Emulsion	2,44	1,22	0,84	0,1	0,1		
		Surfactant	1,42	1,8	1,96	1,96	1,96		
	Salinity 7000 ppm 1%	Oil	0,75	0,75	0,8	1,8	1,82	0,75%	Upper phase
		Emulsion	1,4	1,4	1,1	0,05	0,03		
		Surfactant	1,85	1,85	2,1	2,15	2,15		

Based on observational data, phase behavior testing at a salinity of 7000 ppm with varying concentrations, there were two types of concentrations that succeeded in forming upper phase microemulsions, namely 0.75% and 1% and one type of middle phase microemulsion, namely 0.9%.

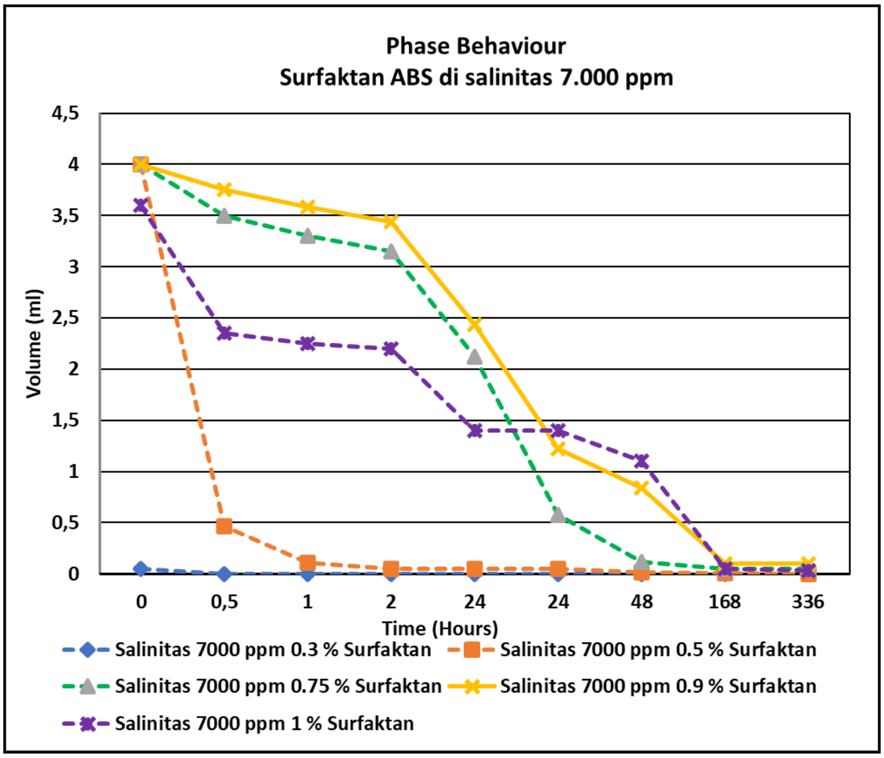

Figure 1. Graph of decrease in ABS surfactant microemulsion phase with respect to time

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In Figure 1 you can see a graph of changes in microemulsion volume versus testing time. It is known that 0.9% ABS surfactant has a stable concentration with the largest volume in phase behavior testing compared to surfactants with other concentrations.

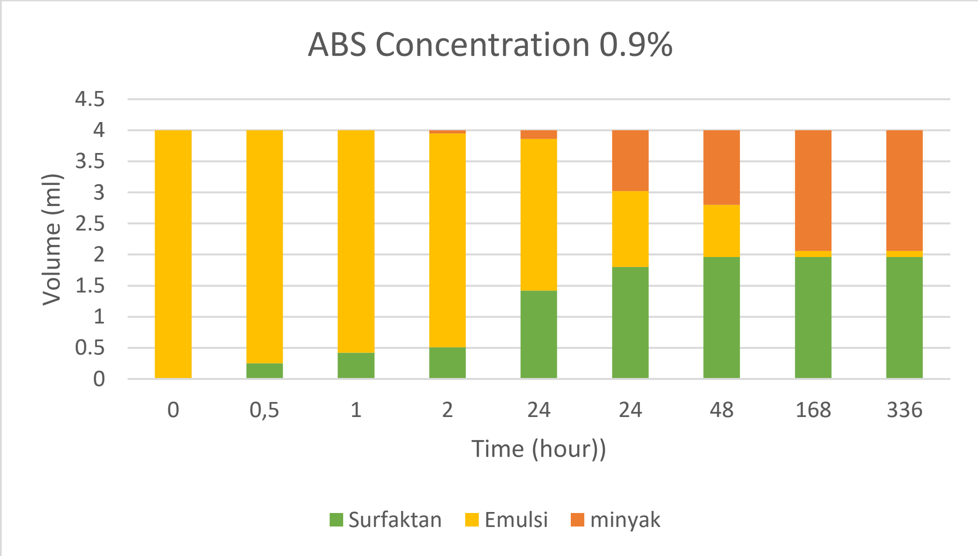

Figure 2. Visualization of microemulsion volume at 0.9% ABS surfactant concentration versus time

Interfacial Tension

IFT value testing was carried out using stable surfactants in phase behavior testing, namely 0.9% ABS surfactant and 1% AOS surfactant. The surfactant and crude oil were entered into a spinning drop tensiometer series TX 500D, then the capillary tube was spun by spinning drop at a rate of 6000 rpm for 30 minutes at a temperature of 80 °C.

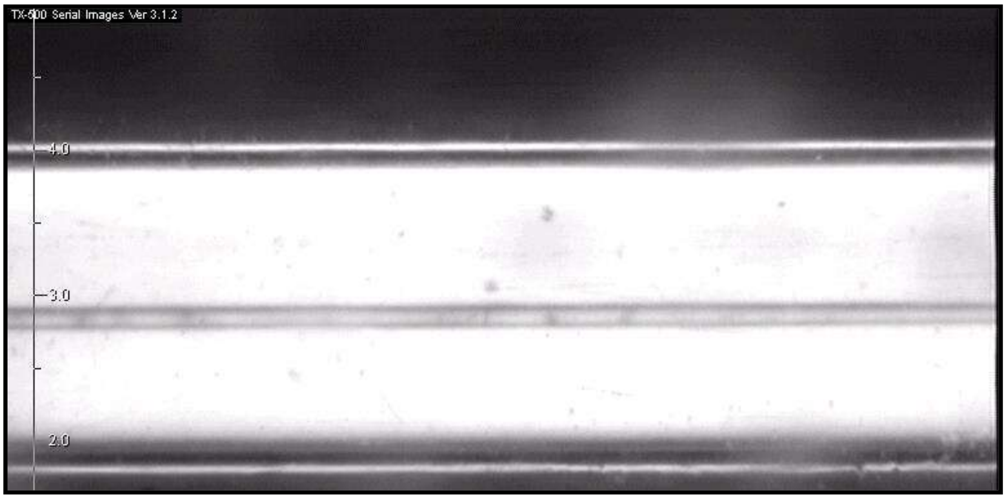

Figure 3. Droplet results of IFT ABS 0.9% testing

Figure 3 is a visualization of the ABS IFT measurement after the TX 500D series spinning drop tensiometer has worked for 30 minutes. It can be seen from the visualization results that the IFT obtained has quite low results seen from the flat droplet shape.

Core Sample Test

Sandstone core or sandstone rock measurements are carried out using a caliper to determine the diameter and height of the rock core so that the bulk volume of the rock sample can be determined. After obtaining the bulk volume, the mass, porosity and

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permeability of the rock samples are measured. The rock is then saturated by soaking it with brine and vacuuming it so that the air inside is replaced by the brine. The rock core to be measured, rock sample A8 has the following size specifications, which can be seen in table 4

Table 4. Measurement of rock samples A8

Nama Core	A8
Rock Type	Sandstone
Diameter (cm)	2.59
Height (cm)	3.714
Bulk Volume (cc)	19.58
Empty weight (gr)	41.673
Weight of brine content (gr)	45.35
Pore volume (cc)	3.91
Porosity (%)	19.97
OOIP (cc)	2.2

Surfactant Injection

Core Flooding testing is carried out using a core holder where the core will be injected with Brine and surfactant which is in accordance with the screening phase behavior results, namely 0.9% ABS surfactant. For water injection, 3 tubes of fluid are injected, while for surfactant injection, 5 tubes of fluid are injected. The injection volume per tube is adjusted to OOIP, namely 2.2 ml. The first to third tubes are a waterflooding process, while the fourth to eighth tubes are a surfactant injection process. The following are the results of the coreflooding test for ABS surfactant.

Table 5. Core Flooding Testing with ABS Surfactant

no	**jenis injeksi**	**fluid out (ml)**	**oil out (ml)**	**brine out (ml)**	**NP Total**	**RF (%)**	**Np Surfaktan**	**RF Surfactant (%)**
0	no inject	0	0	0	0	0	0	0
1	Waterflood 1	2.2	0.75	1.45	0.75	34.09	0	0.000
2	Waterflood 2	2.2	0.01	2.19	0.76	34.55	0	0.000
3	Waterflood 3	2.2	0.03	2.17	0.79	35.91	0	0.000
4	ABS injection 1	2.2	0.1	2.1	0.89	40.45	0.1	4.545
5	ABS injection 2	2.2	0.07	2.13	0.96	43.64	0.17	7.727
6	ABS injection 3	2.2	0.05	2.15	1.01	45.91	0.22	10.000
7	ABS injection 4	2.2	0.1	2.1	1.11	50.45	0.32	14.545
8	ABS injection 1	2.2	0	2.2	1.11	50.45	0.32	14.545
ABS Total Recovery Factor								14.545

In the results from table 5. a graph of crude oil recovery data is obtained when waterflood and surfactant injection are carried out. During the waterflood. 0.79 ml of oil was produced with a recovery factor of 35.91%. When 0.9% ABS surfactant was injected with a salinity of 7.000 ppm. 1.11 ml of oil was produced with a recovery factor of 14.545%. Figure 4 is a graph of the recovery factors obtained per tube.

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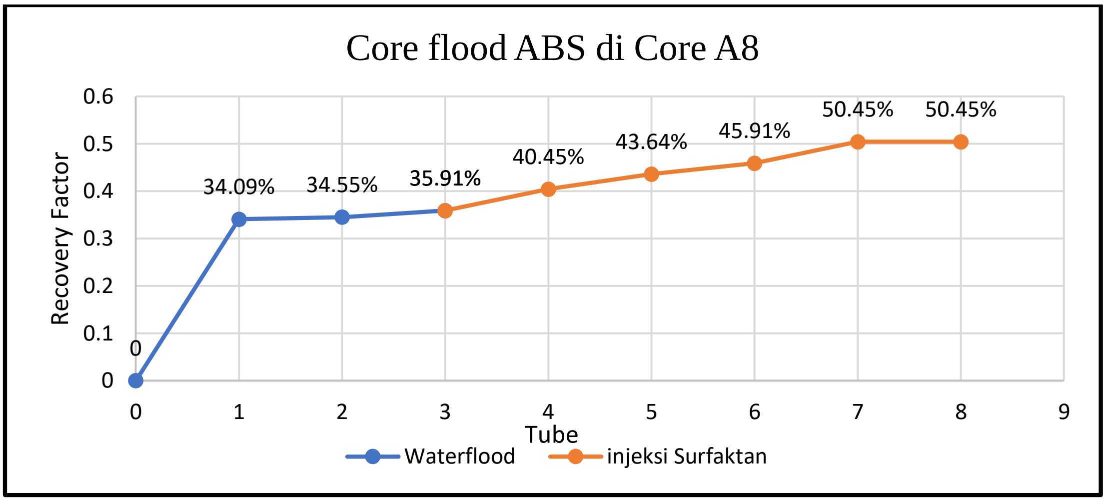

Figure 4. Graph of Recovery factor Value Obtained on ABS Surfactant 0.9% Salinity 7000 ppm

In Figure 5 there are documentation results of oil recovery during the Core Flooding process where the three tubes on the left are the Waterflooding process. while the five tubes to the right are the injection of ABS surfactant 0.9% salinity 7.000 ppm. The following image below shows the results of the coreflooding process.


Figure 5. Oil recovery during ABS surfactant coreflood

CONCLUSION

The conclusion of the research with the title "Laboratory Study of Analysis of the Effect of ABS Surfactant Injection on Increasing Oil Recovery" obtained several final project research results as follows:

1. At temperature 30 °C. ABS density measurement with concentration variations is 1.0001; 1.0012; 1.0014; 1.0015 and 1.0017.
2. At temperature 80 °C. the ABS density measurement with variations in concentration is 0.9515; 0.9740; 0.9745; 0.97481 and 0.9758.
3. In the phase behavior test for seven days. ABS surfactant was obtained. namely surfactant with a concentration of 0.9% salinity 7.000 ppm. this was because the surfactant was close to the middle phase.

4. In the interfacial tension test. the IFT results for ABS surfactant 0.9% (salinity 7000ppm) were 0.0055654 dyne/cm.
5. In the injection of water and ABS surfactant 0.9% salinity 7.000 ppm with rock sample A8. namely when the waterflood produced 0.79 ml of oil with an RF yield of 35.91%.
6. When surfactant was injected. 0.32 ml of oil was produced with a recovery factor of 14.545%.

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ABSTRACT: The decline in oil recovery in oil and gas fields is a problem that must be faced now and in the future along with the increasing need for petroleum energy. Increasing oil recovery reserves requires an advanced method, namely Enhanced Oil Recovery (EOR). Surfactants are one of the enhanced oil recovery (EOR) methods to increase oil recovery. This laboratory research will use a surfactant solution, namely ABS Surfactant (Alkyl Benzene Sulfonate). There are five concentrations for each surfactant, namely 0.3; 0.5; 0.75; 0.9; and 1% with the same salinity of 7,000 ppm. In this study, ABS surfactant was used because the surfactant has the characteristic of being able to reduce interfacial tension. This research carried out a phase behavior test to determine the stability of the emulsion with a measurement time of 7 days at a temperature of 80 °C. Making an ABS surfactant solution, 70% ABS fluid is available where the surfactant raw material will be mixed with brine with a salinity of 7,000 ppm. There are several stages carried out, namely density test, phase behavior, interfacial tension, and core flooding. After making a sample of the ABS surfactant solution, the second step was to carry out a density test using a DMA-4100 densitometer to determine the density of the ABS surfactant solution at temperatures of 30 °C and 80 °C. The third is a phase behavior test where the surfactant solution will be mixed with oil and then placed in an oven at a temperature of 80 °C for 336 hours to obtain emulsion results that are close to the midpoint so that the stability of the emulsion is more optimal. The fourth is to determine the IFT value with a surfactant sample that has the highest volume of microemulsion stability. Finally, the core flooding test is to determine how much oil is recovered from the sandstone when surfactant injection is carried out. In the IFT results, the ABS surfactant solution was able to reduce the interfacial tension well between oil and formation water in the reservoir, where the interfacial tension value was 0.0055654 dyne/cm. The results of core flooding with ABS surfactant with a concentration of 0.9% salinity of 7,000 ppm obtained a recovery factor of 14.545%.

KEYWORDS: Alkyl Benzene Sulfonate, Interfacial Tension, Phase Behaviour, Surfactant, Sandstone.

INTRODUCTION

The decline in oil recovery in oil and gas fields is a problem that must be faced now and in the future along with the increasing need for petroleum energy. Increasing oil recovery reserves requires an advanced method, namely Enhanced Oil Recovery (EOR). EOR is a method that can be used to increase the amount of hydrocarbons that can be obtained from a field after the primary and secondary stages of production have been completed (Massarweh and Abushaikha 2020). There are various EOR methods consisting of chemical injection, gas injection, thermal injection, and microbial injection. Sweeping efficiency can be increased by reducing the oil-water mobility ratio which is influenced by fingering(Kargozarfard, Riazi, and Ayatollahi 2019). Chemical injection, which can be alkaline, surfactant, or polymer. The EOR stage is carried out after the end of the water injection process, if the amount of oil remaining in the reservoir is still quite large (Pauhesti, Kasmungin, and Hartono 2018).

Surfactants are one of the enhanced oil recovery (EOR) methods to increase the recovery of oil and surfactants, including the most commonly found chemical injection methods. This can reduce the interfacial tension between oil and water so that it can sweep oil away from rocks that are oil wet rock (Green, D W 1998) The properties of surfactants are that they can reduce surface tension, interfacial tension, increase the stability of the dispersed particles and control the type of formulation, either oil in water (o/w) or water in oil (w/o) (Schramm, Stasiuk, and Marangoni 2003). The addition of surfactants in a solution will cause a decrease in the surface tension of a liquid solution and the phase interface, both liquid-gas and liquid-liquid (Anastasia Wulan Pratidina Swasono, Putri Dei Elvarosa Sianturi, and Zuhrina Masyithah 2012)

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The physical properties of ABS surfactant such as viscosity and density were measured using the 'Redwood' viscosity method and pycnometer. The physical properties of activated carbon for calculating the minimum fluidization rate such as measuring activated carbon porosity are carried out by measuring the remaining empty space (cavity volume, M3) in packed activated carbon(Sablayrolles et al. 2009). Alkylbenzene Sulfonate (ABS) is starting to be used by manufacturers as a substitute for Branch Alkyl Benzene (BAB) because it is considered more environmentally friendly and easily broken down by microorganisms (biodegradable). Alkylbenzene Sulfonate (ABS) is an anionic surfactant in liquid form with the molecular formula $C_{12}H_{25}C_6H_4SO_3Na$ which is used as a raw material in the detergent industry, apart from that ABS is also used as a material to reduce surface tension or interfacial tension in industry (Deby Febrianty Isba Diputri 2021).

The research was carried out on a laboratory scale with the aim of determining the density and specific gravity obtained with changes in temperature of 30 °C and 80 °C in brine, crude oil, and ABS surfactant. From the physical test process, it was found that the higher the concentration of the food solution, the values of density, viscosity, and specific gravity would also increase (Nugraha et al. 2022a, 2022b). To determine the nature of the interfacial tension of ABS surfactant on Crude Oil, before carrying out the IFT test, first carry out a phase behavior test to determine the appropriate salinity and type of emulsion that can be mixed with crude oil to reduce the interfacial tension or to studied the behavior of hydrocarbon mixtures, salinity, and surfactant systems at cold temperatures(Gao and Sharma 2013). Several opinions state that this behavior test is a faster test stage and makes it easier to determine the IFT value and the effectiveness of the performance of the surfactant solution being tested(Dian Farkhatus Solikha 2021). Good results in this phase behavior test are that surfactants with a certain concentration and salinity form a middle-phase emulsion (Riswati et al. 2020) In this case, the mid-phase emulsion is one of the main mechanisms that shows the success of EOR using surfactants other than oil-surfactant IFT values of less than 10 mN/m; reducing the IFT of oil and other fluids and controlling wettability in rock pores (Marques and Silva 2013).

Surfactant injection is widely used in EOR techniques because the application technique is relatively simple and the recovery obtained is relatively large compared to conventional water injection. The mechanism for increasing recovery with surfactants reduces interfacial tension, reduces the mobility of the pressing fluid, and communicates with a wider reservoir volume limit. The increase in surfactant concentration to form micelles is called higher critical micelle concentration (CMC) to achieve the desired mobility control(Arina and Kasmungin 2018). The working mechanism of surfactants in reducing interfacial tension, the hydrophilic part (likes water) will enter a polar solution and the lipophilic part (likes oil) will enter a non-polar solution so that the surfactant will combine two compounds that cannot actually combine (Anggie Suci Meilanie 2021).

Apart from that, this research uses sandstone rock samples as reservoir media. Reservoir rocks are permeable rocks, namely porous rocks where the pores are interconnected so that they can pass fluids with different densities and viscosities (Peters 2012).

METHOD

The research was carried out in the enhanced oil recovery (EOR) laboratory, Faculty of Earth and Energy Technology (FTKE), Trisakti University. The research work steps carried out in this laboratory included preparation for making synthetic formation water, making surfactant solutions, measuring the physical properties of the solution, measuring stress. interface and ABS surfactant injection. The materials used in this research were ABS (Alkyl Benzene Sulfanoate) surfactant solution with a concentration of 0.3; 0.5; 0.75; 0.9 and; 1% with a salinity of 7,000 ppm, crude oil with an API of 41°API.

The series of preparations and experiments carried out in this laboratory began with making a solution, namely brine and surfactant, then testing the physical properties of the solution, namely density at temperatures of 30 °C and 80 °C, then interfacial tension at a temperature of 80 °C. After that, the most optimum solution was selected, measurements were carried out at a concentration of 0.3; 0.5; 0.75; 0.9, and 1%. The next step is to test the Interfacial Tension value using the Spinning Drop Tensiometer Series 500D which is based on the balance of centrifugal force and interfacial tension (Gao and Sharma 2013). To get the CMC or Critical Micellar Concentration point, where to find the lowest and most economical interfacial tension point.

The salinity of the formation water used in this research is 7,000 ppm, so as not to reduce the ability of surfactants to increase oil recovery from the model, it is made by dissolving 7 grams of NaCl in 1000 ml of distilled water which will be stirred with a magnetic stirrer. The oil used in this research is light oil with an API value of 41°API.

Fluid density and specific gravity are measured using a tool called a Density meter. Meanwhile, measuring the interface tension uses a Spinning Drop Tensiometer Series 500D. To test ABS surfactant injection into sandstone rocks using a Core holder.

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CONCLUSION

There are several research stages and their results, namely making a surfactant solution, density test of the surfactant solution, phase behavior test, interfacial tension test of the surfactant solution, measuring sandstone cores, and core flooding testing. These seven things have reliable results because this research is primary data that is directly examined objectively in the laboratory.

Density Test

Density or density testing uses a tool called the Densitometer DM-4100. Where testing using a densitometer includes the density and Specific Gravity of a surfactant solution, brine, and Crude Oil. The results of density testing can be seen in table 1 regarding the density and specific gravity of crude oil and brine.

Table 1. Density and Specific Gravity Crude oil and Brine

Sample name	Temperature (deg C)	API	Densitas (gr/cc)	SG
Rantau *crude oil*	30	41,3561	0,816	0,8186
	80	45,2424	0,7786	0,8006
Brine 7.000 ppm	30	-	1,0001	1,0044
	80	-	0,9687	0,9968
Aquadest	30	10	1	1

Next, testing the ABS surfactant using a Densitometer can determine the density and Specific Gravity. Carried out first at a temperature of 30 °C after completion, then changed to a temperature of 80 °C. This takes a long time because the temperature of 80 °C takes time to rise due to the gradual increase in temperature on the densitometer, if it is not done properly there will be an error in the reading of the instrument.

Table 2. ABS Surfactant Density and Specific Gravity

Surfactant sample	Surfactant concentration (%)	Temperature (°C)	Density (gr/cc)	SG
ABS 1	0,3	30	1,0001	1,0042
		80	0,9515	0,9792
ABS 2	0,5	30	1,0012	1,0044
		80	0,9740	1,0028
ABS 3	0,75	30	1,0015	1,0044
		80	0,9745	1,0026
ABS 4	0,9	30	1,0015	1,0045
		80	0,9748	1,0031
ABS 5	1	30	1,0017	1,0045
		80	0,9758	1,0042

Phase Behaviour

The phase behavior test was carried out on field X oil samples with ABS surfactant and AOS surfactant, where this test used a 4 ml tube for seven days and was heated to a temperature of 80 °C in an oven. The crude oil phase behavior test with ABS surfactant (0.3; 0.5; 0.75; 0.9; 1%) was carried out at a temperature of 80°C and a salinity of 7000 ppm.

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Table 3. ABS phase behavior test results

Oil	ABS Surfactant Composition	Phase	Volume at Observation Time (hours)					Total emulsion (%)	Types of Phase Emulsions
			2	24	48	168	336		
X 45,24 °API	Salinity 7000 ppm 0,3 %	Oil	2	2	2	2	2	0,00%	None
		Emulsion	0	0	0	0	0		
		Surfactant	2	2	2	2	2		
	Salinity 7000 ppm 0,5 %	Oil	1,9	1,9	1,95	1,96	2	0,00%	none
		Emulsion	0,05	0,05	0,02	0,01	0		
		Surfactant	2,05	2,05	2,03	2,03	2		
	Salinity 7000 ppm 0,75 %	Oil	0,3	1,47	1,85	1,9	1,9	1,25%	Upper phase
		Emulsion	2,12	0,58	0,12	0,05	0,05		
		Surfactant	1,58	1,95	2,03	2,05	2,05		
	Salinity 7000 ppm 0,9 %	Oil	0,14	0,98	1,2	1,94	1,94	2,50%	Middle phase
		Emulsion	2,44	1,22	0,84	0,1	0,1		
		Surfactant	1,42	1,8	1,96	1,96	1,96		
	Salinity 7000 ppm 1%	Oil	0,75	0,75	0,8	1,8	1,82	0,75%	Upper phase
		Emulsion	1,4	1,4	1,1	0,05	0,03		
		Surfactant	1,85	1,85	2,1	2,15	2,15		

Based on observational data, phase behavior testing at a salinity of 7000 ppm with varying concentrations, there were two types of concentrations that succeeded in forming upper phase microemulsions, namely 0.75% and 1% and one type of middle phase microemulsion, namely 0.9%.

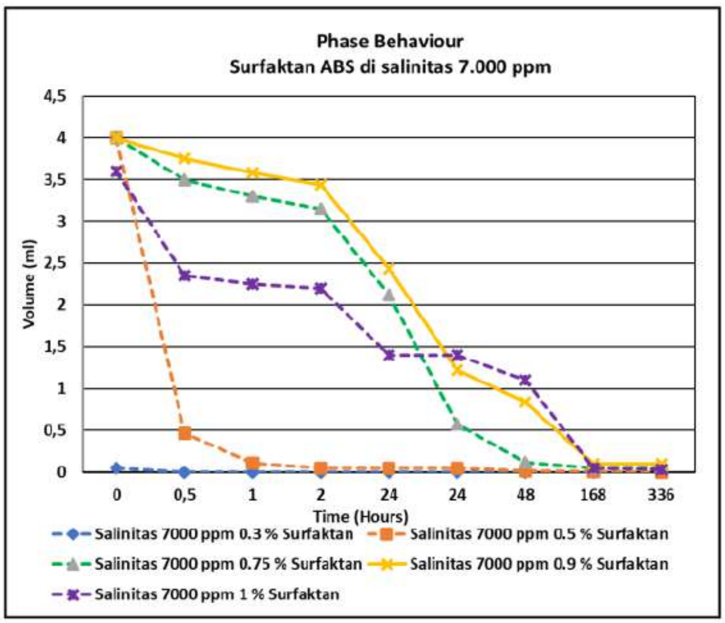

Figure 1. Graph of decrease in ABS surfactant microemulsion phase with respect to time

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In Figure 1 you can see a graph of changes in microemulsion volume versus testing time. It is known that 0.9% ABS surfactant has a stable concentration with the largest volume in phase behavior testing compared to surfactants with other concentrations.

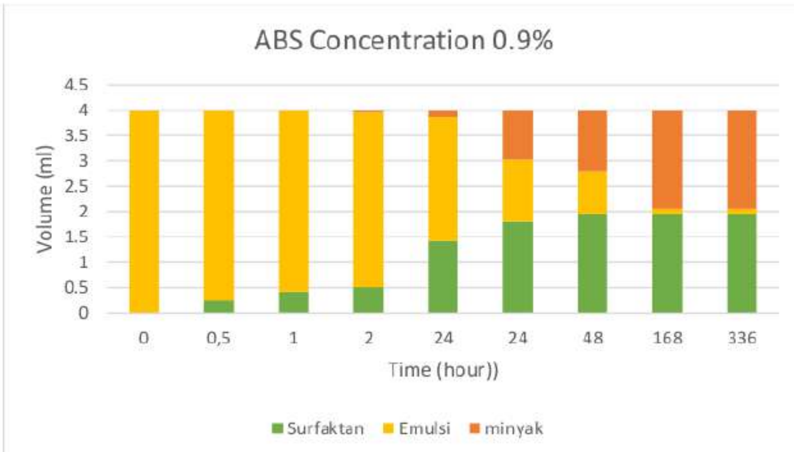

Figure 2. Visualization of microemulsion volume at 0.9% ABS surfactant concentration versus time

Interfacial Tension

IFT value testing was carried out using stable surfactants in phase behavior testing, namely 0.9% ABS surfactant and 1% AOS surfactant. The surfactant and crude oil were entered into a spinning drop tensiometer series TX 500D, then the capillary tube was spun by spinning drop at a rate of 6000 rpm for 30 minutes at a temperature of 80 °C.

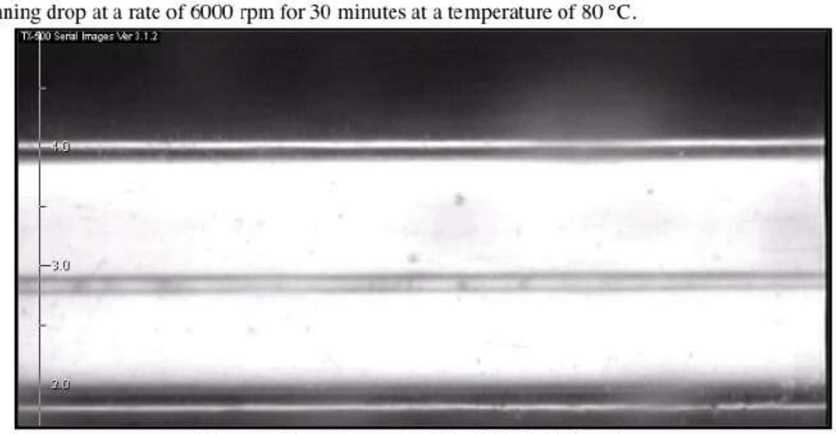

Figure 3. Droplet results of IFT ABS 0.9% testing

Figure 3 is a visualization of the ABS IFT measurement after the TX 500D series spinning drop tensiometer has worked for 30 minutes. It can be seen from the visualization results that the IFT obtained has quite low results seen from the flat droplet shape.

Core Sample Test

Sandstone core or sandstone rock measurements are carried out using a caliper to determine the diameter and height of the rock core so that the bulk volume of the rock sample can be determined. After obtaining the bulk volume, the mass, porosity and

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permeability of the rock samples are measured. The rock is then saturated by soaking it with brine and vacuuming it so that the air inside is replaced by the brine. The rock core to be measured, rock sample A8 has the following size specifications, which can be seen in table 4

Table 4. Measurement of rock samples A8

Nama Core	A8
Rock Type	Sandstone
Diameter (cm)	2.59
Height (cm)	3.714
Bulk Volume (cc)	19.58
Empty weight (gr)	41.673
Weight of brine content (gr)	45.35
Pore volume (cc)	3.91
Porosity (%)	19.97
OOIP (cc)	2.2

Surfactant Injection

Core Flooding testing is carried out using a core holder where the core will be injected with Brine and surfactant which is in accordance with the screening phase behavior results, namely 0.9% ABS surfactant. For water injection, 3 tubes of fluid are injected, while for surfactant injection, 5 tubes of fluid are injected. The injection volume per tube is adjusted to OOIP, namely 2.2 ml. The first to third tubes are a waterflooding process, while the fourth to eighth tubes are a surfactant injection process. The following are the results of the coreflooding test for ABS surfactant.

Table 5. Core Flooding Testing with ABS Surfactant

no	**jenis injeksi**	**fluid out (ml)**	**oil out (ml)**	**brine out (ml)**	**NP Total**	**RF (%)**	**Np Surfaktan**	**RF Surfactant (%)**
0	no inject	0	0	0	0	0	0	0
1	Waterflood 1	2.2	0.75	1.45	0.75	34.09	0	0.000
2	Waterflood 2	2.2	0.01	2.19	0.76	34.55	0	0.000
3	Waterflood 3	2.2	0.03	2.17	0.79	35.91	0	0.000
4	ABS injection 1	2.2	0.1	2.1	0.89	40.45	0.1	4.545
5	ABS injection 2	2.2	0.07	2.13	0.96	43.64	0.17	7.727
6	ABS injection 3	2.2	0.05	2.15	1.01	45.91	0.22	10.000
7	ABS injection 4	2.2	0.1	2.1	1.11	50.45	0.32	14.545
8	ABS injection 1	2.2	0	2.2	1.11	50.45	0.32	14.545
ABS Total Recovery Factor								14.545

In the results from table 5, a graph of crude oil recovery data is obtained when waterflood and surfactant injection are carried out. During the waterflood, 0.79 ml of oil was produced with a recovery factor of 35.91%. When 0.9% ABS surfactant was injected with a salinity of 7.000 ppm, 1.11 ml of oil was produced with a recovery factor of 14.545%. Figure 4 is a graph of the recovery factors obtained per tube.

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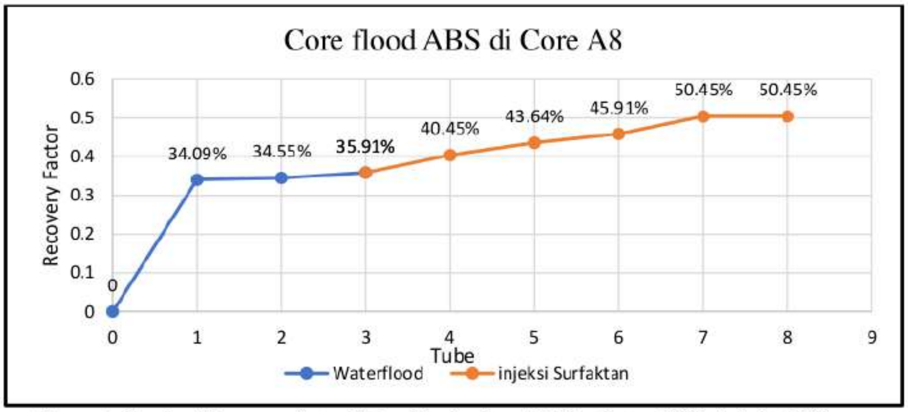

Figure 4. Graph of Recovery factor Value Obtained on ABS Surfactant 0.9% Salinity 7000 ppm

In Figure 5 there are documentation results of oil recovery during the Core Flooding process where the three tubes on the left are the Waterflooding process. while the five tubes to the right are the injection of ABS surfactant 0.9% salinity 7.000 ppm. The following image below shows the results of the coreflooding process.

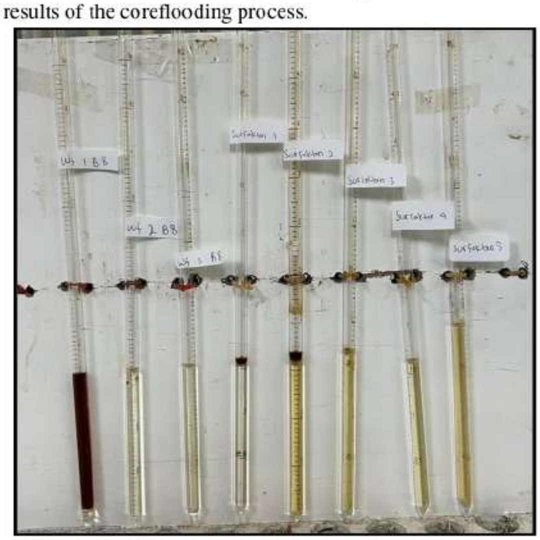

Figure 5. Oil recovery during ABS surfactant coreflood

CONCLUSION

The conclusion of the research with the title "Laboratory Study of Analysis of the Effect of ABS Surfactant Injection on Increasing Oil Recovery" obtained several final project research results as follows:

1. At temperature 30 °C. ABS density measurement with concentration variations is 1.0001; 1.0012; 1.0014; 1.0015 and 1.0017.
2. At temperature 80 °C. the ABS density measurement with variations in concentration is 0.9515; 0.9740; 0.9745; 0.97481 and 0.9758.
3. In the phase behavior test for seven days. ABS surfactant was obtained. namely surfactant with a concentration of 0.9% salinity 7.000 ppm. this was because the surfactant was close to the middle phase.

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4. In the interfacial tension test. the IFT results for ABS surfactant 0.9% (salinity 7000ppm) were 0.0055654 dyne/cm.
5. In the injection of water and ABS surfactant 0.9% salinity 7.000 ppm with rock sample A8. namely when the waterflood produced 0.79 ml of oil with an RF yield of 35.91%.
6. When surfactant was injected. 0.32 ml of oil was produced with a recovery factor of 14.545%.

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