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EFFECT OF SURFACTANT CONCENTRATION AND NANOSILICA ADDITIVE TO RECOVERY FACTOR WITH SPONTANEOUS IMBIBITION TEST METHOD

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ABSTRACT: In an effort to improve oil recovery, there are several methods in a chemical that have been proven to be successfully applied, one of them which is the application of surfactants flooding. However, the effectiveness of the surfactant so limited to reach the broader reservoir zone as there is already considerable oil depleted in the primary and secondary recovery. So in this research used nanosilica additives as a solution to maximize the performance of surfactants to able the smaller pores and distant rocks to improve the oil recovery factor. The result can be known using the spontaneous imbibition test method. Laboratory research consisted of two main processes: manufacture of artificial core and spontaneous imbibition test. In the manufacture of artificial cores, cores are made by mixing quartz, cement and bentonite, with variations of additive nanosilicaa saturated on the artificial core. The spontaneous imbibition test was performed using brine 10000 ppm mixed with five different surfactant concentration from 0.1%, 0.25%, 0.5%, 0.75% until 1%. Based on the results of the research, it was found that core with the use of additive nanosilica with 0.5% surfactant concentration solution resulted in optimum recovery factor with 34.7% value compared to the core without nanosilica with RF of 31.8%. If the surfactant concentration to be added so recovery factor will continue to decrease.

Keywords: Artificial Core, Brine, Recovery Factor and Spontaneous Imbibition Test.

1. INTRODUCTION

Indonesia's oil production since the last decade has continued to decline. Based on SKK Migas 2015 annual report [1] there are many factors causing the decline of national oil production such as a factor of an oil field in Indonesia which is generally mature, and then various equipment production facilities of old oil and gas fields. Approximately 65% of pipelines, 57% offshore platforms, 55% of tanks and vessels, 44% of rotary equipment, and 35% of turbomachinery are older than 1980 SKK Migas 2015. Beside this, current demand for petroleum consumption continues to increase along with an increase in time, but this condition was not able to be followed by increased production of petroleum in Indonesia. According to the Head of the Special Working Unit for Upstream Oil and Gas Upstream Activities of Upstream Oil and Gas at the end of 2018, national oil and gas production only reached 834 thousand barrels/day. This is not proportional to the national consumption demand of 1.6 million barrels/day. This is worrying enough for all of us, and this situation demands the role of relevant agencies and national petroleum engineering experts to think harder about the breakthroughs that can be taken to improve the recovery of the increasingly limited oil.

To overcome this problem, born EOR technology that is actively applied today as well as chemical injection, thermal, and miscible. There is also the usual chemical injections are alkali, surfactant and polymer. Recently chemical injections have begun to penetrate the nanomaterial domain to obtain more efficient factor recovery. The nanomaterials most currently like Al_2O_3, MgO, Fe_2O_3 and SiO_2 [2] Nanomaterials are the result of material manipulation on the atomic scale and molecular scale to make the material in the nanoscale. If nanomaterials combined with EOR may increase oil yields. Because the nanomaterials with very small size will easily get into the pores of the rocks even the smallest. This is similar as revealed by [3] states that aluminum oxide and silicon dioxide can act as a good agent for EOR.

Mursyidah Umar, Novia Rita and Ayyi husband in 2015 [4] stated that the use of nanosilica additives success for increase oil recovery water flooding recovery factor in rock with cases that have low porosity and permeability. If similar research is conducted on higher porosity and permeability it will certainly be able to increase the recovery factor. However, a comprehensive review is needed to investigate whether additives can also improve the recovery factor in other chemicals.

In this research, researchers tried to combine the use of surfactants with nanosilica additives to improve the recovery factor. The research itself was conducted in the Petroleum Engineering Reservoir Laboratory of the Islamic University of Riau. In addition, this study was conducted to determine the effect of the use of nanosilica additive in flooding surfactant to the recovery factor. So that evaluation of the use of nanosilica additive in the future can be applied to surfactant flooding on a larger scale.

2. MATERIALS

2.1 Chemical

The anionic surfactant used was alpha olefin sulfonat (AOS), which was identified as a good foaming agent and good condition to improving oil recovery.

2.2 Nanoparticles

Nanoparticles that choose in the research is nanosilica nanoparticle. Nanosilica used researcher nanosilica commercial especially for (R & D) with white powder shape with 10-20 nm size at available in laboratory petroleum engineering.

2.3 Core sample

Sample core used in the research is artificial core and manufactured with mixing quartz, cement, bentonite and water. Core sample in this research may be meaning like "Artificial core".

2.4 Crude Oil

Crude oil used was taken from a light oil field located in the central of sumatera, Indonesia. The properties of the crude oil sample are presented in Table 2.

2.5 Amot Cell

Amott cell or imbibition cell used for determining oil recovery dan percentage of recovery factor. Amott cell is more or less like a burette with a precision scale of 0.1 ml so that the use of the tool will show more to minimize errors that occur when reading the value. The recovery factor approach using this tool is even able to match the use of core flooding, the results will be more actual if done with a long test time. About amot cell can be seen at fig.1.

Fig.1 Amot Cell

3. EXPERIMENTAL

Artificial core as reservoir model was used to spontaneous imbibition Test experiment. The artificial cores made in this research consist of two main variations, the first being a mixture of quartz, cement and bentonite with the addition of some water. While the second artificial core variation there is the addition of nanosilica additive. The comparison between quartz sand, cement and bentonite in the manufacture of artificial core is 60: 24: 5 and the addition of water by 10% of the total weight of mass while artificial core with nanosilica there is an addition of 0.2 gram additive nano silica so that the comparison becomes 60:24: 5: 0.2.

The next step in determining porosity with the first fluid saturation by weigh the dry core and weigh the core, cores saturated by crude oil, with crude oil density data so that the volume of oil that enter into the pores can be obtained. By comparing the volume of crude oil that fills the core pores with the bulk core volume, the core porosity value can be obtained.

$$\varphi = \frac{V\ pore}{V\ Bulk} \times 100\% \qquad (1)$$

Meanwhile, for the physical properties of crude oil such as API crude oil obtained by weighing and viscosity of crude oil obtained through correlation glass. With formula:

$$^{O}API = \frac{141.5}{SG} - 131.5 \qquad (2)$$

As for surfactant solution obtained by making surfactant solution with volume ratio principle, which used brine 10000 ppm as dilution which is representative of water formation. For each type of solution is made as much as 600 ml. The amount of surfactant, brine and total volume used for each variation of the surfactant solution is shown in table 1 below:

Table 1 Variation of surfactants concentrations

Combi nations	Concentrations (%)				
	0.1	0.25	0.5	0.75	1
SF(ml)	0.6	1.5	3	4.5	6
Brine (ml)	599.4	598.5	597	595.5	594
∑ (ml)	600	600	600	600	600

Determination of recovery factor in this research through imbibition test using amott cell is done by soaking artificial core into a water bath which has been made in different solution at a certain temperature, It should test imbibisi done until there is no more increase of oil which read by amott cell burette (Plateu), but due to limited time constraints on the use of the laboratory, so the researchers only do 1 day test (24 hours) for 1 test sample. So, scematic about experiment can look at fig.2

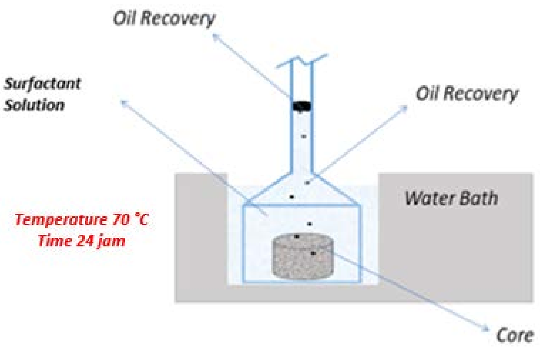

Fig.2 Schematic spontaneous imbibition test

4. RESULT AND DISCUSSION

Based on the result of the research, it is found that porosity and permeability of cores are obtained with range 29% - 34% and permeability in the range 422- 978 mD it indicates porosity and permeability of cores is excellent and very good [5].

Although the core produced in this study is not completely uniform, it is when viewed from the value of porosity and from permeability, but the core is good enough to be said identical because the core is still in the same quality that is special porosity category and permeability excellent according to Koesoemadinata year 1980. So researchers believe that the quality of porosity and permeability of the cores produced would be optimally used for imbibisi test with a variation of surfactant concentration and by imbibisi test with the use of nanosilica additive

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Table 2 Core properties

Core	Porosity (%)	Permeability (mD)
1#	29.3%	515.67
2#	28.6%	474.24
3#	28.7%	476.97
4#	28.7%	478.51
5#	29.9%	557.65
6#	29.6%	535.58
7#	27.8%	422.23
8#	29.2%	509.47
9#	33.7%	890.01
10#	34.5%	978.40
11#	33.4%	858.18

Meanwhile, for the properties of crude oil where crude oil is used as research material has a good API with a value of 32.72 and crude oil viscosity with a value of 2.17 cp. It shows the oil is very good.

Table 3 Crude oil properties

Properties	Value	Unit
SG oil	0.86	Gr/cc
API	32.7	-
Viscosity	2.27	Cp

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4.1 Determination of Recovery Factor with Surfactant

Before the imbibition test with a surfactant, the first one was an imbibition test using brine at a salinity of 10000 ppm. In this test, brine is used as a representation of water formation due to the unavailability of water formation from an oil field in this research. Brine 10000 ppm, in this case, is also called a base case because in the 10000 ppm brine imbibition test this solution is made not added with other substances that later can change the properties between oil and water later. The addition of NaCl at the time of brine manufacture of 10000 ppm is only as a representation of water formation only, because in the water formation In this research the researchers decided to use salinity of 10000 ppm on the grounds that surfactant flooding has its own screening criteria where flooding surfactants are suitable at salinity <20000 ppm. The excess of Na and Cl on brine is also not good for the effectiveness of the surfactant solution, making a surfactant solution will not be able to work optimally, this is in accordance with research conducted [6] where high levels of salinity water formation will affect the surfactant's performance in lowering the surface tension so that the oil obtained will not be optimal, this is due to NaCl when dissolved with water. Then NaCl will break down into Na^+ and Cl^-. As for the surfactant molecules, themselves have the RSO_3H molecular formula so that when dissolved in water will break down into molecules H^+ and $SO3^-$. So when the two molecules are later dissolved in water it will cause the cations and anions of different molecules to bind, wherein the H^+ derived from the surfactant molecule will bind to Cl^- derived from the salt as well as Na will bind to the $SO3^-$ so that later formed is HCl and $NaSO_3$ and it is clear that this newly formed compound is not a surface active agent. So salinity becomes an important consideration before surfactant flooding.

The imbibition test to determine the effect of surfactant concentration started from variation of concentration 0.1%, 0.25%, 0.5%, 0.75%, to 1% with spontonaeous Imbibition Test.

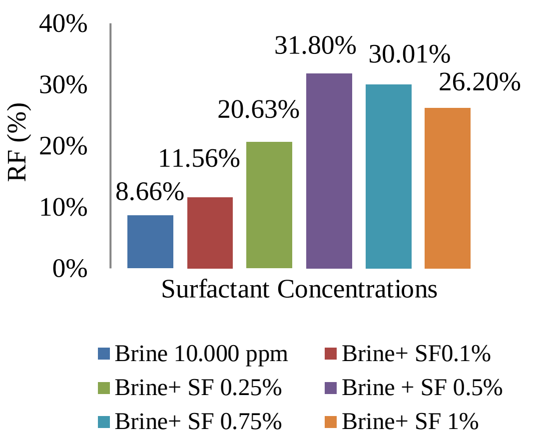

Fig.3 Relation % RF with Surfactant Concentrations

Based on Fig.3, at concentration of 0.1- 0.5% it appears that the greater the concentration of surfactant used in the urgent solution, the recovery factor will increase, this is because many of the surfactant monomers comprising hydrophobic and hydrophilic groups react with oil , this will cause the surface tension between the water and the oil is getting smaller, so oil is easily produced, it will directly be able to improve the recovery factor produced. The greater the concentration of the surfactant used in the urgent solution, the more volume or form of energy entering into the deeper pores to change the wetness of the rock and urging the oil to exit from the rock [7] .

But it can be seen that the concentration of surfactant 0.75% to 1% decreases the percentage of RF, it is caused because the surfactant has saturated at point 0.5% surfactant concentration where in the conditions the surfactant not work well for separate oil in water. although the surfactant concentration is enhanced even after passing through the saturated point, the surfactant will be saturated so that the surfactant will no longer be effective as a surface active agent which will decrease the interface tension between oil and water, it is seen in percent of RF concentrations at 0.75% and 1% which tended to decrease compared with 0.5% concentration. So from the picture above shows the optimum concentration of surfactant is at 0.5% concentration because at that concentration is able to produce the most optimum RF percentage of 31.80% compared to other concentrations.

4.2 Determination of Surfactant Recovery Factor and Use of Nanosilica Additive

The imbibition test at this stage is actually the same as the imbibition test on brine and on brine + surfactant, the difference being this stage is the core used in this research ie the core that has been mixed additives in it during the manufacture of the core. The test is carried out while maintaining the other constant variables such as the size of the core used the salinity of the solution, the heating temperature, the nanosilica concentration and the page of observation time. The recovery product of each difference of surfactant concentration tested is shown in fig.4.

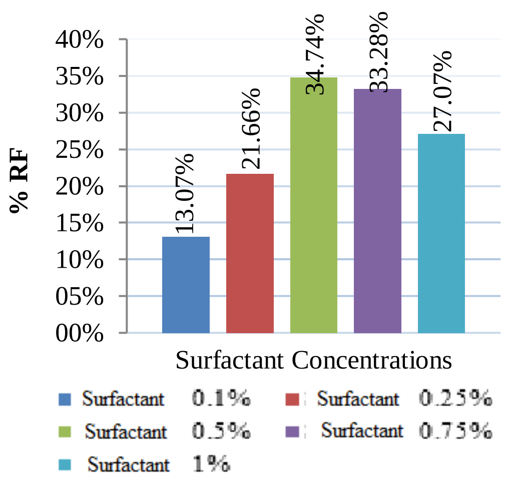

Fig.4 Relationship of surfactants concentrations with a recovery factor

4.3 Influence Analysis of Surfactant Concentration and Use of Additive Nanosilica

Based on the experiments that the researchers analyzing the effect of surfactant concentration variations and the use of nanosilica additives on the cores.

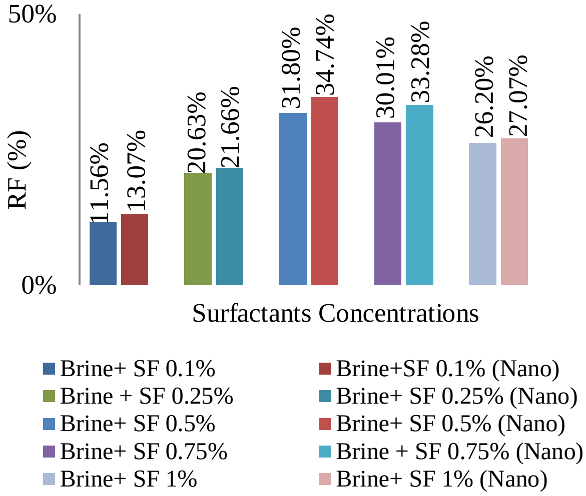

Fig.5 Relation of surfactants concentrations with using nanosilica additive to recovery factor

Fig.5 above shows the effect of surfactant concentration and the use of nanosilica additive in artificial core. It is seen in Fig.5 that cores containing nanosilica additives produce a greater percentage of RF than cores without the use of nanosilicas, this is due to the repulsive force between the surfactant heads being negatively charged due to the presence of the RSO_3 group- with negatively charged sandstone rocks the presence of silica compounds (SiO_2^-). This repulsive force causes the oil-binding surfactant on the part of the R group to move away from the rock and this will result in the wettability of the rock being turned into water wet. The use of nanosilica additives here will make the rocks and pathways of rock pores more richer with silica elements derived from previously saturated nanosilica additives. So with that the oil on the rock surface and the rock pores will move away from the rock because the oil is tied to the tail of the anionic surfactant that will move away because the rock is rich in silica that is negatively charged [9].

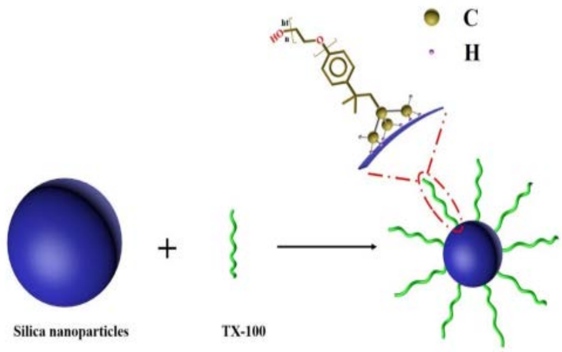

Fig.6 Ilustrated of Mechanism Nanosilica with Surfactants Process [11]

The process on cores containing nanosilica is actually more or less the same mechanism but the rock without the use of nanosilica, the difference is only on silica-rich content or not on the surface or on the pore. Rocks that have previously been saturated with nanosilica as will tend to be more negatively charged than cores without the use of nanosilica additives, this is due to the influence of the amount of silica elements present in the rock. So it certainly will make the core with the use of additive nanosilica will more effectively release the oil compared to cores without nanosilica[9].

In addition to these processes nanosilica very active role in changing the wettability of rocks from oil wet to water wet or from water wet to strongly water wet [10]. It is this nanosilica nature that is the difference between cores that use nanosilica with cores without nanosilica. Seen on fig.5 core images using nanosilicas gives the RF percent greater than cores without nanosilica additives. Although the same urgent fluid uses a surfactant that serves to convert the wettabillity of rock from oil wet to water wet but that is certainly not as effective as cores that use nanosilica because nanosilica on one side will also alter the wettability of rocks so here there are two agents that will change the wettability of rock from oil wet to water wet.

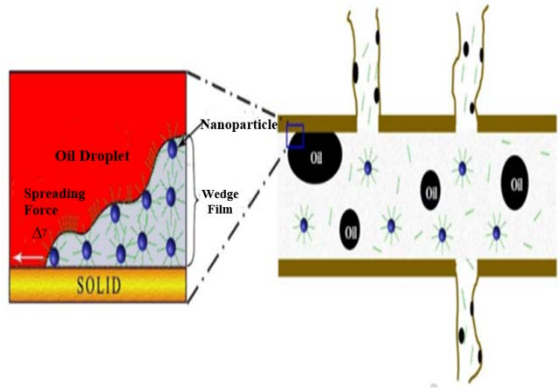

Fig.7 Ilustrate dispersed Nanosilica In Rock [12]

The picture above illustrates how the nanoparticles can be dispersed or enter into the gap between the surface of the rock and the oil grains. By modifying the nanoparticles, the oil granules are initially sticky on the surface of the rocks to become loose and finally can make the oil more easily flow through the path flow to the bottom of the well to be produced to the surface.

5. CONCLUSION

From this research, the conclusion is as follows: Based on measurement of porosity and determination of artificial core permeability obtained value range 29-34% and 422-978 mD which indicate porosity and permeability is very good. Physical properties of crude oil obtained is API 32.17 which indicates as Light Oil (light oil). The use of nanosilica additives with small concentrations actually can improve the recovery factor compared to non-additive surfactants with an increase of ± 3%.

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