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Effect of Nanosilica Injection to Oil Recovery Factor in Low Porosity and Permeability Reservoir

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Abstract

Porosity and permeability can be affected to oil recovery. Low porosity and permeability problems may cause oil flow from reservoir to wellbore becomes more difficult. A reservoir model has been prepared with 10.82% porosity and 28.8 mD Permeability using 30 mesh of homogenous sandstone. Nanosilica solution in water injection has been conducted in reservoir model. The result showed 5 % recovery factor incremental by injecting continuously 0.1% nano silica solution at 5 psi pressure. This means nanosilica injection has been successfully increase oil recovery.

Keywords: Nanosilica, Homogenous Sandstone, Low porosity, low permeability, Recovery Factor

Introduction

Low oil production becomes a serious issue in crude oil industry. Improvement to crude recovery has been applied. Using artificial lift, acids stimulation, or even create artificial fractures in reservoir can increase the production. But, all of those efforts still leaving Small portion of crude oil trapped in reservoir. These remain oils becomes a target for Enhance Oil Recovery (EOR) application.

The First method to enhance oil recovery was waterflood. This method is the easiest way because to displace oil, only water is needed. Various waterflood implementation have been applied to improve oil recovery. From brine coreflood experiments, oil recovery can improve to 67% of the original oil in place (OOIP) (Robetson et al , 2003) while optimization using simulator study gave slightly same 67.51% (Ikram, 2012). From these researches, a conclusion may be made that there are many barrels of oil still trapped in reservoir after waterflood method was applied. Laboratory and simulation study confirmed that some oil still trapped in smaller pore and some other made thin film at grain's surface. From experiments conducted by Zhao, 2010, the higher initial water saturation tends to make reservoir more water wet. So, less water wet condition should be created to improve oil recovery. It is a challenge for nanotechnology application in oil and gas industry.

Nanotechnology is atomic or molecular engineered material in nanometer scale, usually range from one hundred to one nanometer (Engeset, 2012). The unique properties of the material usually optimized for special purposes. Nanomaterial has been used for many cases in industry including oil and gas. Its efficiency, low cost, and friendly environmental characteristic can be used in exploration, drilling, and Enhanced Oil Recovery.

This paper reports the effect of nanosilica injection on low permeability and low porosity reservoir. nanosilica act as additive at EOR process. Using nanosilica as additive since silica is the most dominant mineral in sandstone reservoir. Good recovery factor in oil displacement process can be great expectation.

Experimental

Cylindrical synthetic sandstone reservoir model was used to nanosilica injection experiment. The model contains 160 grams mesh 30 sand, 40 grams cement, and 15 ml fresh water. Porosity and permeability were measured by Porosimeter and permeameter portable apparatus.

First step in determining porosity was bulk sample and steel plug volume calculation using cylinder equation. Dead volume parameter was obtained from volume reading with steel plug inside while gauge reading was obtained from volume reading with sample inside. Grain volume was calculated by subtracting steel plug volume with gauge reading and dead volume. Subtraction of sample bulk volume with grain volume yield pore volume. Porosity can be obtained by dividing pore volume with bulk volume.

Permeability measurement based on Darcy equation by using single phase nitrogen flow. Four data obtained from permeameter are high flow, low flow, high DP, and low DP data. High DP data obtained from pressure differential record for high flow rate while low DP data obtained from pressure differential record for low flow. Flow area can be calculated by circle equation. Along with nitrogen viscosity, using Darcy equation, permeability can be calculated.

Injection apparatus consist of 50 ml injection tube that was connected to cylindrical model chamber. To push the fluid into the chamber, a low pressured air from compressor can be applied. This chamber was made from solid steel with two valves as fluid's inlet and outlet (Fig. 1).

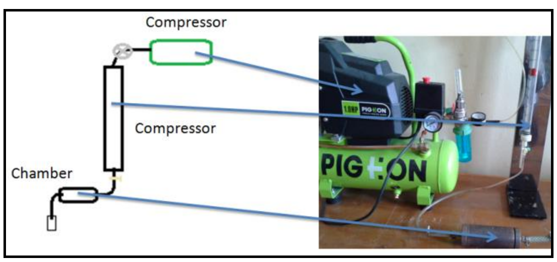

Fig. 1 : Injection Tool Apparatus

Paraffin was used to replace hydrocarbon fluid in the reservoir model. Before injection, the reservoir model was saturated with paraffin for 24 hours. After saturation, the model was placed in the chamber.

Injection process divided into 3 stages with same 5 psi injection pressure. First stage, model was injected 200 ml fresh water. In second and third stage, fresh water with 0.1 %wt and 0.2 %wt nanosilica inject into the model. All effluents that come out from the model were measured.

To study the reservoir mineralogy after injection process was tested by X-Ray Difraction (XRD) in PANALYTICAL X'PERT PRO with K-Alpha1 (Å) 1.54060 wave length.

Result and Discussion

By applying cylinder volume equation, bulk volume for this reservoir was 37.06 cm^3 and grains volume was 33.06 cm^3. Subtraction of bulk volume to grain volume yields 4.01 cm^3. Dividing pore volume with bulk volume yields 10.82% porosity.

From permeameter apparatus, two flow rate data which were obtained: 0.75 cc/s for high flow rate and 0.6483 cc/s for low flow rate. Differential pressure measurement resulted in 0.72789 atm for high DP and 0.70816 atm for low DP. Permeability calculation using Darcy Law yield 28 mD for 0.018 cp Nitrogen viscosity permeability. This means the model has low porosity and low permeability.

There were 15 ml paraffin was initially accumulated in model's pore after saturation process. Effluent from water injection process resulted in 0.7 ml paraffin. .By adding 0.1% wt nanosilica into 200 ml fresh water as injection fluid, this injection process results 0.75 ml additional effluents. The effluents production increase into 0.8% if 0.2% wt nanosilica dispersed in water was injected.

Recovery factor calculation can be obtained by dividing paraffin production from the model with paraffin initial volume in model. According to recovery factor, adding 0.1% wt nanosilica can increase recovery factor from 4.67% by water injection to 9.67%. Increase nanosilica concentration in water about 0.2% wt cause recovery factor increment to 15%. Researches on nanosilica concentration effect on recovery factor are still in progress.

Figure 2 shows the mineral of reservoir models using XRD. From this figure, can be seen that the sample reservoir models is the sandstone rock, where sandstone (SiO_2) was shown on the peak at its °2Th 20.7522 (°2Theta). While nanosilica that flowing through model's pore or even may be trapped in the reservoir is still on progress.

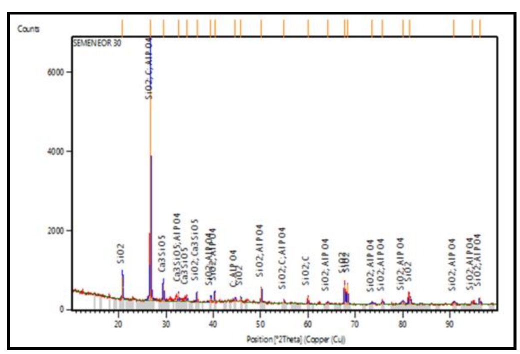

Fig. 2 : XRD Result for Reservoir Sample

Conclusion

Laboratory experiments has successfully proved that nanosilica injection may effects to increasing oil recovery in low porosity and low permeability reservoir.

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