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An Experimental Investigation of Wettability Alteration of Carbonated Rock Using Alpha-Alumina Nanofluid

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INTRODUCTION

Nowadays according to demand for energy and limitation in oil and gas production attention has turned to new technologies for distribution and enhancing hydrocarbon exploration and production. Nanotechnology has potential and ability to improve an oil industry. Recently, the application of nanoparticle suspension for water flooding and enhanced oil recovery has been proven. Different kind of nanoparticles have been used for promoting enhanced oil recovery, including, non-metal nanoparticles (Silicon, carbon nanotube), metal oxide nanoparticles (Zinc oxide, Nickel oxide, Iron oxide, Titanium oxide, Copper oxide) and metal nanoparticles (Nickel, Iron, Copper)[1–8]. These nano materials have been utilized and enhanced oil recovery in distinct manner. Nanoparticles have been used for reducing produced oil gravity [9, 10], upgraded reservoir heat transfer [2], wettability alteration [8] and etc., however wettability alteration is the prevalent key factor between them in order to promote oil displacement and enhance oil recovery

In this study, the effect of Alpha Alumina nanofluid has been investigated on wettability alteration of carbonated reservoir. Design expert has been employed to studied main parameter means nanoparticles concentration and pH on wettability alteration of carbonated reservoir.

METHODOLOGY

NANOFLUID PREPARATION

Alumina nanofluid were prepared from Alumina nanopowders. Firstly, according to table of experimental design proper amount of Alumina nanoparticles was added to distilled water. The obtained mixture has been ultrasonicated.

In next step, according to the table of experimental design appropriate amount of surfactant (SDS) has been added to nanofluid, and solution has been ultrasonicated for 5 min. In next phase, pH has been adjusted, and stable nanofluids by the means of sediment photograph capturing have been selected for next part.

PREPARATION OF CORE SLICES

After completion of first part and determination of stable nanofluid, thin section of carbonated reservoir have been prepared. Thin sections have been cut from core samples that have been made ready from carbonated reservoir, and these slices are 1.5 inches in diameter and 3 millimeter in thickness. Slices have been ultrasonicated in water bath for 20 min, and next, slices have been dried for 12 hours in oven. After thin sections have been washed and dried, thin sections should be prepared and aged in oil to alter wettability of slices from water-wet to oil-wet.

AGING PROCESS

After preparation of core slices, contact angle of these samples have been analyzed and measured. Thin sections have been aged in crude oil for a three month to alter the original wettability of core from water-wet to oil-wet as they were in carbonate reservoir. Slices contact angle are measured, afterwards aging process have been done. The contact angles of carbonated slices are illustrated in Figure 1 before and after aging process in crude oil.

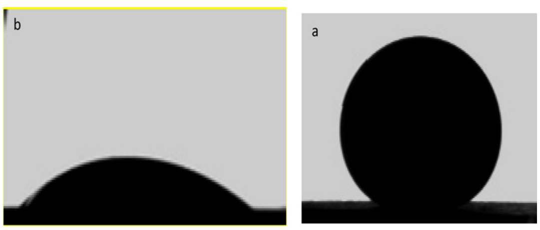

Figure 1: contact angle of carbonated slices before and after aging process in crude oil (a) before aging process (b) after aging process.

The oil-wet slice of core have been aged in nanofluid for 1,2,3,4 and 5 hours, and after each time period the contact angle of slices have been measured.

RESULTS AND DISCUSSION

WETTABILITY ALTERATION

Figure 2 shows the contact angle of slices that aged with stable nanofluids .Moreover, it can be seen from Figure 2 that all stable nanofluids altered wettability of core slices from oil-wet to water-wet or intermediate. The difference in nanoparticle concentration and pH of nanofluids affect the wettability of core slices and oil recovery.

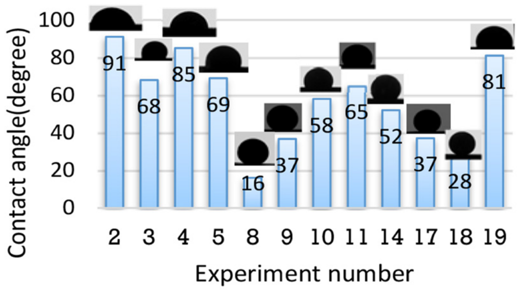

Figure 2: Contact angle of slices VS. Experiment number.

As shown in figures 3, when the nanoparticles concentration of prepared nanofluids increase contact angle of slices become lower and enhance oil recovery were improved. Higher concentration of nanoparticles cause fabricating and formation of more complete layer of water-wet layer of alpha Alumina and it means reducing in contact angle. Figure 4 showed the effect of pH on reduction of contact angles. If potential of nanoparticles in base fluid are nearing its Point of zero charge, the repulsion between metal oxide particles will become zero and as result nanoparticles agglomeration will be accrued. Agglomeration of nanoparticles causes obstruction reservoir pores and decreasing of porosity of reservoir and this fact is there that neither does it improve oil production, nor does it leads to higher extraction of oil (i.e. the major problem reduces the extraction of oil).

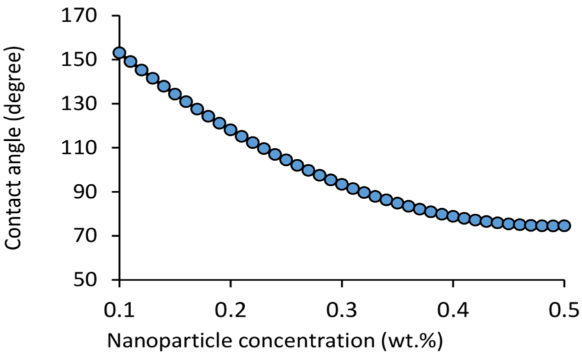

Figure 3: Contact angle of slices VS. Nanoparticle concentration (wt. %) in pH 7.5.

EOR process may change the crude oil/brine/rock properties by two mechanisms: coating and cleaning. Coating attributes to the process of covering the oil-wet layer by water-wet materials. Alumina nanoparticles are hydrophilic, and when they are adsorbed in the rock surface, and nano texture coating the oil-wet surfaces is created. In addition, wettability is altered to more water-wet. Cleaning mechanism is normally associated with surfactant induced wettability alteration. Cationic surfactants, for instance, desorb the oil-wet layer and thus restore the surface to a more water-wet state.

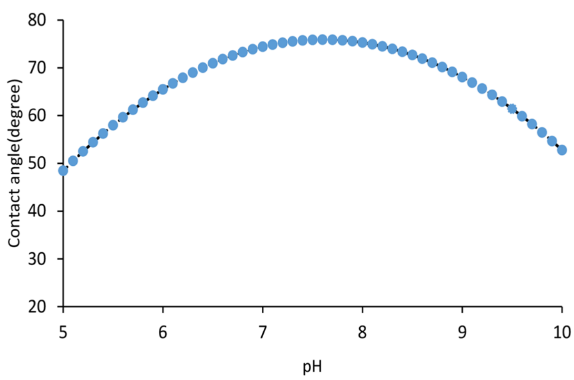

Figure 4: Contact angle of slices VS. pH in nanofluid with 0.3 wt% alpha Alumina.

CONCLUSION

In this article, the experimental research effect of alpha Alumina nanofluids on contact angle of reservoir has been investigated. Also, the effect of nanofluids pH is checked. Before analysis of wettability and contact angles of reservoir samples, the stability of nanofluids has been explored. According to results and outcomes of contact angle measurement, it has been seen that:

-Increasing nanoparticles concentration up to 0.5 wt.% causes a reduction in contact angle, and diminution of contact angle till 20 ^{o}C is possible. Moreover, it has been accrued because of hydrophilic nanoparticles layer formation on reservoir. Reservoir altered from oil-wet to water-wet.

-Nanofluids with low pH(acid) and high pH(alkaline) that to be far from zero potential have appropriate stability as the result adsorption of nanoparticles on rock has been increased.

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