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Contents

Application of nanotechnology for regulation the rheophysical properties of water-oil emulsions

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Abstract.

In this paper, application of nanoparticles for regulation of rheophysical properties of water-oil emulsions were considered.

The effect of Al_2O_3 nanoparticles on the rheological characteristics of the emulsion is shown by the results of laboratory experimental research.

As a result of the application of the proposed technology for downhole oil demulsification, well productivity increased.

Keywords: water-oil emulsions, rheology, nanotechnology, Al_2O_3 nanoparticles, downhole demulsification.

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1. Introduction

The problem of stable water-oil emulsions separation is very important for oilfields at the final stage of well production.

The well production process has a considerable influence on the cost of oil production. Therefore, an individual approach to the problem of deemulsification is necessary not only for different fields, but even for each wells [1].

The process of splitting water-oil emulsions depends on many factors: oil properties (oil density, viscosity, component composition, etc.); properties of formation water (mineralogical composition); the presence of solid particles (clay, gum, etc.); the presence of natural emulsifiers and stabilizers, etc. [2-7].

Various methods of breaking water-oil emulsions are used: thermal, chemical reagents at high temperature, gravity separation (sedimentation), filtration separation, centrifugation, ultrasonic separation, electric effect, magnetic effect, etc.

The main method of field preparation of oil is thermochemical deemulsification and a lot of chemical reagents are used that reduce the surface tension between oil and water.

The modern synergetic approach to the oil demulsification process is based on the application of a combined physicochemical effect.

A promising and actual approach to increase the efficiency of the deemulsification process of highly viscous and stable water-oil emulsions is the joint application of nanotechnologies and physicochemical effects [8].

In this paper, application of Al_2O_3 nanoparticles for regulation the rheophysical properties of water-oil emulsions was considered.

2. **Experimental Apparatus and Methodology**

It is proposed to apply Al_2O_3 nanoparticles for water-oil emulsion separation. To this, nanoparticles are previously dissolved in a specific reagent.

Later, two test cells filled with 5% sulfate solution prepared in water were taken. 5% Al_2O_3 nanoparticles was added to one of the test cells. Both test cells were hermetically sealed and the contents were thoroughly mixed. Then, the mixture inside both test cells is separately added to equal amounts of emulsions taken from one well.

The mixture in the test cell with added Al_2O_3 nanoparticles separated for 3 min and the separation was observed by gas bubbles. In the second test cell, the separation time took several hours. It should be noted that the amount of oil released in the test cell with added nanoparticles is significant.

The reaction was carried out a second time, and at this time the composition of the mixture was taken in the following ratio: Al_2O_3 nanoparticles - 22.3% of composition; specific reagent 33.1%; H_2O was 44.6%. $6\cdot10^3$ g of specific reagent and $8\cdot10^{-6}$ m^3 of water were used for every $4\cdot10^3$ g of nanoparticles during the field experiment carried out.

As a result of the reaction, hydrogen release is observed at an intense rate. Then the resulting solution was added to the water-oil emulsion. As a result, the emulsion was separated in 5-10 minutes.

As a result of laboratory studies, the optimal component composition of the mixture was determined: 0.01% Al_2O_3 nanoparticles, 0.99% reagent.

The viscosity of oil and emulsions was determined by keeping the given temperature constant for 10 minutes using a rotary viscometer. The average value of the velocity gradient was 0.56 m/sec.

The dependence of the dynamic viscosity of emulsion and oil taken from well show on figure 1.

Due to the fact that the viscosity of the oil is smaller than viscosity of the emulsion, as a result of the application of the proposed methodology, the volume of produced oil increases.

Thus, the rheological characteristics of the viscometric studies conducted on the emulsion oil sample taken from the well allow us to conclude that adding 0.01% of Al_2O_3 nanoparticles, the viscosity of the studied system is significantly reduced and the emulsion, to the elements of which it is composed (water and to oil) is broke.

The effects of nanoparticles on the change of the oil structure were studied.

Processing of emulsion oils by the proposed method results to the transition of oil from non-Newtonian to Newtonian fluid character.

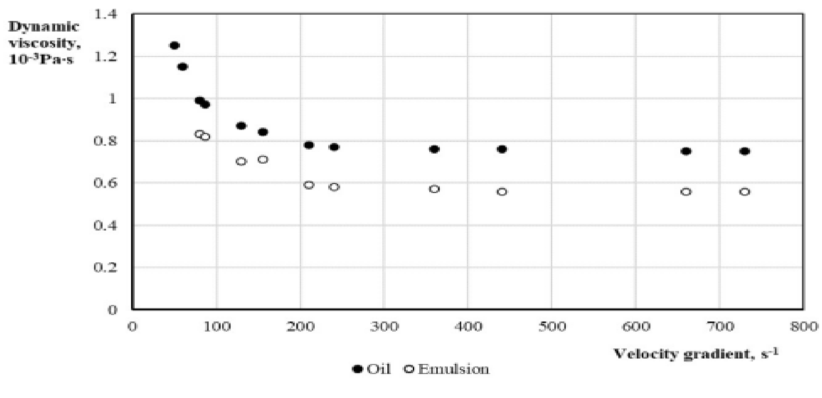

Fig.1. Dynamic viscosity of oil and emulsion (T=25°C)

3. **Field Case**

It is necessary to have information about the viscosity of degassed water-oil emulsions at different temperatures in the high dilution range (10-60%).

Let's analyze the effect of the proposed reagent on the viscosity of the water-oil emulsion.

Figure 2 shows the dynamic viscosities of the emulsions with different percentages of water and oil taken from well, as well as measurements of the viscosity of pure oil during decomposition by reagent and Al_2O_3 nanoparticles.

It can be seen that the presence of 5% water causes the viscosity of the break emulsion to decrease relative to the oil viscosity. The viscosity of water and 5% oil solution is already several cPs.

Figure 3 shows the measurements of the dynamic viscosity of the emulsion taken from the well until the demulsifier is introduced. The viscosity of the emulsion is significantly greater than the viscosities of water and oil. Comparisons of figures 2 and 3 show that the viscosity of the emulsion broken by the added reagent drops to the level of the comparable water viscosity. If we take into account that the produced liquid of well contains 60-80% water, it can be concluded that the fluid behaves like an ideal fluid.

Changing the rheological properties can result to an increase in liquid rate. However, maintaining the volume of injected gas at the previous level is accompanied by a decrease in liquid flow rate.

Thus, it is necessary to adjust the injected gas consumption to maintain the liquid rate of the well at a high level.

The effect of alkaline waste, dust and chemical preparation on the rheological properties of water-oil emulsion was studied. Figure 4 shows the dynamic viscosity of the emulsion taken from the well before and after the introduction of alkaline residue, as well as the dynamic viscosity of the combination of the emulsion with alkaline waste, aluminum powder and chemical preparation. It can be seen from the picture that the injection of alkali waste reduces the viscosity of the oil by half. The injection of Al_2O_3 nanoparticles dissolved in the alkali waste and the chemical preparation reduces the viscosity of the oil by four times.

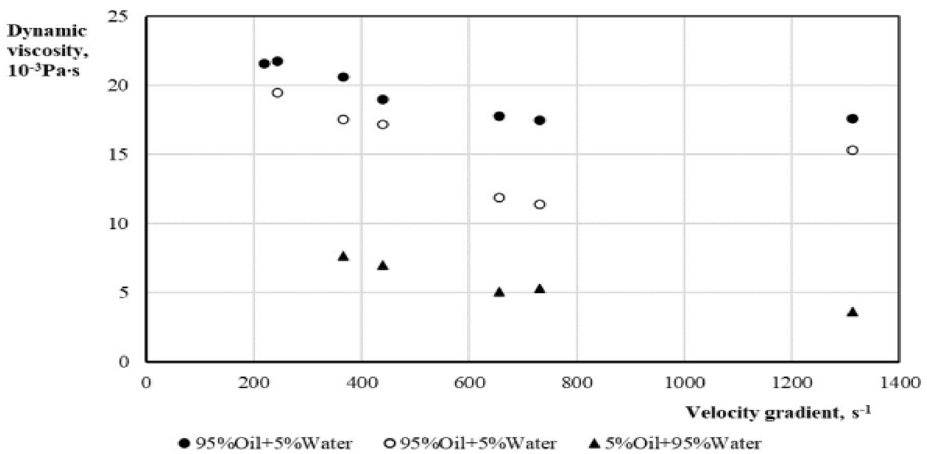

Fig.2. Dynamic properties of emulsions during decomposition.

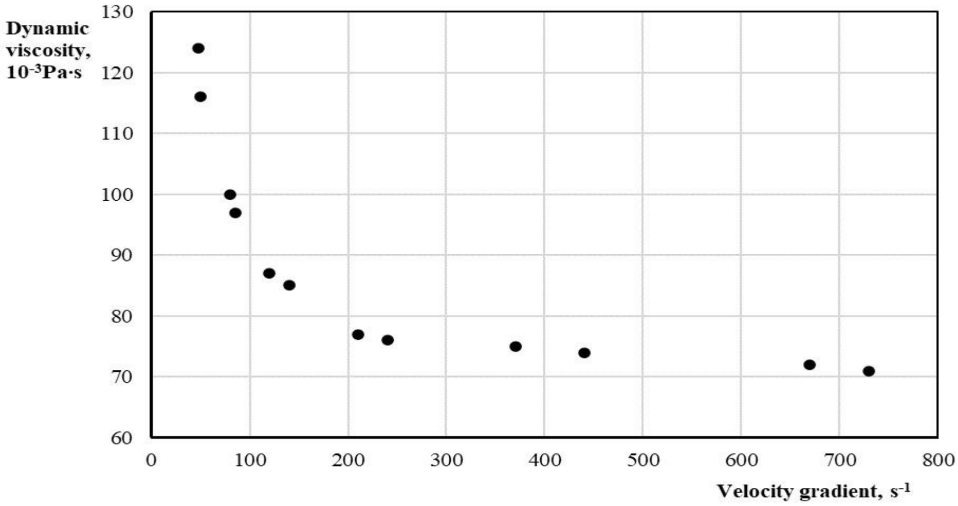

Fig.3. Viscosity of the emulsion.

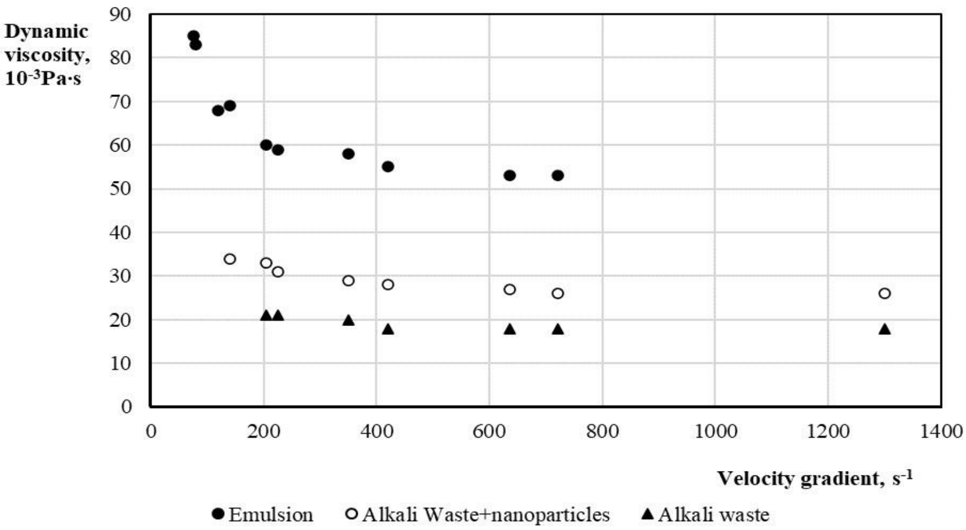

Fig.4. Effect of alkaline waste and nanoparticles on the dynamic viscosity of the emulsion

The developed technology for breaking water-oil emulsion with Al_2O_3 nanoparticles was tested in production well (table 1)

Table 1.

Change of parameters of a well during application of Al_2O_3 nanoparticles

Days	Method of influence	Pressure, bar	Liquid, t	Oil, t	Water, t	Oil fraction
1	Emulsion breaker	53				
2	Emulsion breaker	53				
3	Emulsion breaker	53	58	8	50	0.137931
4	Emulsion breaker	53	56	8	48	0.142857
1	Emulsion breaker+nanoparticles	53				
2	Emulsion breaker+nanoparticles	52	74	11	63	0.148649
3	Emulsion breaker+nanoparticles	51	70	10	60	0.142857
4	Emulsion breaker+nanoparticles	52				
5	Emulsion breaker+nanoparticles	52				
1	Nanoparticles	52	70	10	60	0.142857
2	Nanoparticles	53				
3	Nanoparticles	53	56	8	48	0.142857
4	Nanoparticles	55	55	8	47	0.145455
5	Nanoparticles	53	54	7	47	0.12963
6	Nanoparticles	53				
7	Nanoparticles	53	54	7	47	0.12963
8	Nanoparticles	53				
9	Nanoparticles	53	47	7	40	0.148936
10	Nanoparticles	53	61	9	52	0.147541
11	Nanoparticles	53	48	7	41	0.145833
12	Nanoparticles	53	46	6	40	0.130435
13	Nanoparticles	53	46	5	41	0.108696
14	Nanoparticles	53				
1	Emulsion breaker	52	58	9	49	0.155172
2	Emulsion breaker	52				
3	Emulsion breaker	47	59	8.8	50	0.149153
4	Emulsion breaker	48	60	8.8	50	0.146667
5	Emulsion breaker	48	59	8.5	50.5	0.144068
6	Emulsion breaker	48	58.3	8.3	50	0.142367
1	Emulsion breaker+nanoparticles	49	60	9	51	0.15
2	Emulsion breaker+nanoparticles	48	62	9	53	0.145161
3	Emulsion breaker+nanoparticles	49	63	8.8	54.2	0.139683
4	Emulsion breaker+nanoparticles	48	62	8.6	53.4	0.13871
5	Emulsion breaker+nanoparticles	48	64.4	9.02	55.38	0.140062
6	Emulsion breaker+nanoparticles	49	67	10.22	56.78	0.152537
7	Emulsion breaker+nanoparticles	49	70.2	10.44	59.76	0.148718
8	Emulsion breaker+nanoparticles	47.3	68	10.15	57.85	0.149265
9	Emulsion breaker+nanoparticles	49	71	8.325	62.675	0.117254
10	Emulsion breaker+nanoparticles	49	61	9	52	0.147541
1	Nanoparticles	49.4	60	9	51	0.15
2	Nanoparticles	51	57	8	49	0.140351
3	Nanoparticles	51.2	57	8	49	0.140351
4	Nanoparticles	52	57	7.4	49.6	0.129825

Application of offered nano-technology increase oil production by 25 tons in two weeks.

4. Conclusions

The influence of nanoparticles on the rheological characteristics of oil-water emulsions was shown.

A technology for downhole demulsification using Al_2O_3 nanoparticles has been proposed.

Application in an oil field showed the effectiveness of the proposed technology and increased the productivity of production wells.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research.

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