Considerations for Using a Hydraulic Fracturing Fluid for Breaking Crude Oil Emulsion from Reservoir

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In the oil industry, crude oil emulsions appear very frequently in almost all activities, starting with drilling and continuing with completion, production, transportation and processing. They are usually formed naturally or during oil production and their presence can have a strong impact on oil production and facilities. In this paper we addressed the problem of oil emulsions present in a reservoir with unfavorable flow properties. It is known that the presence of emulsions in a reservoir can influence both flow capacity and the quality of its crude oil, especially when they are associated with porous medium's low values of permeability. Considering this, we have introduced a new procedure for selecting a special fluid of fracture. This fluid has two main roles: to create new flow paths from the reservoir rock to wells; to produce emulsion breaking of emulsified oil from pore of rocks. Best fracturing fluid performance was determined by laboratory tests. Selected fluid was then used to stimulate an oil well located on an oil field from Romania. In the final section of this paper,we are presenting a short analysis of the efficiency of the operation of hydraulic fracturing stimulation probe associated with the crude oil emulsion breaking process.

Keywords: *emulsion, crude oil, emulsion breaking agent, hydraulic fracturing, emulsion stability index*

Emulsions are colloidal systems, in which fine droplets of a liquid are dispersed in another liquid. The two liquids are non-miscible. If water droplets are dispersed in the oil, the emulsion is W/O (water/oil) type, and if the oil droplets are dispersed in water, the emulsion is O/W (oil/water) type. Emulsions could have a beneficial effect and are used in different areas, such as: food industry, pharmaceutical industry, medicine, paints, cosmetics, agriculture, metallurgical industry, oil industry, etc. [1].

Problems regarding emulsions' applications/ implications in the oil industry occur in almost all activities related to the field: drilling, completion, production, transportation, processing.

If during drilling, using emulsions can be an advantage in order to improve the quality of drilling fluid, emulsions appearance at the production stage, either formed naturally in the reservoir rocks or generated during production operations, is not useful. Their presence requires performing emulsion breaking treatments to avoid inconveniences that may arise in future activities: storage, transport and processing. Also, the presence of water in oil can cause undesirable problems such as corrosion, increased conductivity, additives elutriation, etc. Due to all these effects, the use of emulsions breaking methods is required. Last, but not least, the emulsion's building up can determine the increase of the reservoir fluid's viscosity, depending on the ratio oil - water and the existing types of emulsion [2]. The most common methodologies used for emulsions' treatment are the thermal and chemical ones (chemical emulsion breakers) [3-5]. These methods are appropriate to determine the emulsions' destabilizing, followed by a period of stabilization to allow gravitational separation to appear. The chemical method still seems to be the most common method for solving the problems that appear emulsified oil saturated reservoirs' case or to prevent the formation of oil emulsions during the production process.

In this paper, a selection procedure for the demulsifier with the best efficiency in the destabilization of oil emulsion is presented. The emulsion oil samples are from a well located in an oil field in Romania. At the same time, the demulsifier (emulsion breaker) must be compatible with the fracturing fluid that will be used to stimulate the reservoir. There was also presented the results obtained after the stimulation process.

Experimental part

Laboratory experiments

The chemical method for emulsion breaking is the most used method for treating oil emulsions [5]. This method uses chemical additives, in order to accelerate the process of breaking the emulsion. A series of laboratory tests are necessary to evaluate the performance of various demulsifiers and to determine the most efficient one [2, 3]. Experimental works were performed at the laboratory of S.C. TACROM SERVICE S.R.L of Ploiesti.

The laboratory experiments presented in this paper were done using the oil emulsion from well A, selected for a hydraulic fracturing operation [6].

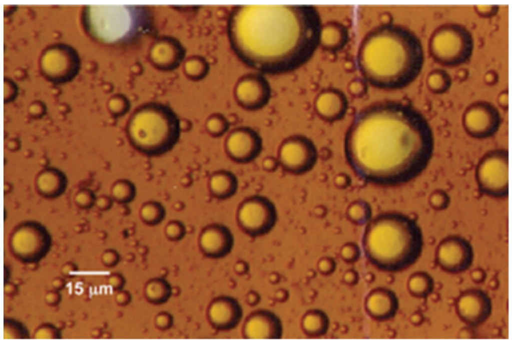

Fig. 1. A water-in-oil emulsion

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Table 1
DATA OF EMULSION AND ADDITIVES AND RESULTS OF EMULSION BREAKING WITH DIFFERENT DEMULSIFIERS

No.	Demulsifier type	Demulsifier concentration (%)	Emulsion (cm^3)	Impurities (cm^3)	Water separated (cm^3)	Water separated (%)
1.	TRS DE 1	1	100	39	37	**94.87**
2.	DEZ R	1	100	39	36	**92.31**
3.	MEA 6	1	100	39	16	**41.03**
4.	G 50	1	100	37	36.5	**98.65**

The emulsion formed when crude is mixed with water was the oil-in-water type (fig. 1) [7].

Usually, adding various special additives to avoid and prevent oil emulsification is necessary in fracturing fluids. In this case, we tested the possibility of oil demulsification into the reservoir at the same time with the hydraulic fracturing because the crude oil was emulsified. This thing has been done with four types of demulsifiers: TRS DE 1, MEA 6, DEZ R, G 50. The testing was done using a classic bottle test procedure. The testing consisted of mixing the crude oil and emulsion breaking agents (stated above) for 15 minutes at speed of 3000 rpm, in a 1% concentration.

Subsequently, the resulting mixture was placed at 60°C, the temperature of the reservoir rock, checking from time to time and recording the amount of water separated during 24 h.

Other data about quantities and concentrations of used substances, emulsion, additives, as well as the total amount of separated water are presented in table 1 [8].

Results and discussions

During these tests, observations were made regarding the measuring of quantities in separate stages, in time. The amount of separated water is expressed as water fraction, F_w, and was determined as the ratio between the volume of separated water, V, at a given moment and the total volume of separated water (impurities), V_0, expressed as a percent [9], respectively:

$$F_w = \frac{V}{V_0} \quad (1)$$

So, it was found that all the water was sAeparated during the first 2 hours for three emulsion breaking agents, and for the fourth (G 50), the amount of separated water continued to increase, even though the accumulation was relatively small. The amount of water increased from 35 cm^3 in the first 2 h to 35.5 cm^3 after 3 h and to 36.8 cm^3 after 24 h. It can also be noted that the lowest recoreded separation efficiency was for the MEA 6 demulsifier. The results of the measurements are shown in figure 2.

Also, the emulsion stability was monitored by measuring the extension of the gravitational separation of the phases. The Emulsion Stability Index (ESI) was calculated, using the following equation [10]:

$$I = \frac{\sum F_n}{n} \quad (2)$$

where:

I - emulsion stability index,

F_w – fraction of salt water at a certain time for a given concentration of the demulsifier, expressed as a percentage of the total amount of impurities and

n - the number of experiments.

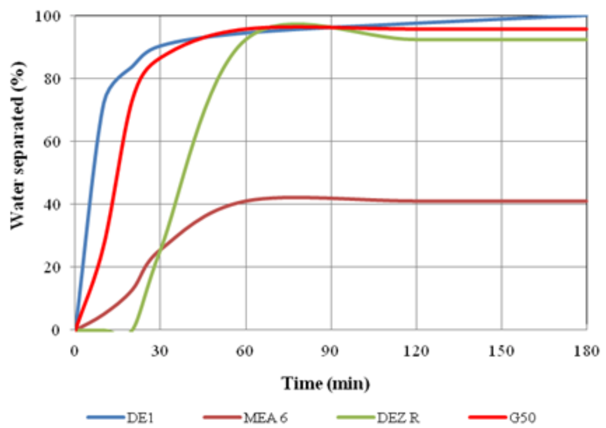

Fig. 2. Demulsifers efficiency for emulsion providing from Well A at 60°C

A similar relationship of ESI calculation, based on monitoring results of phase separation process, was presented in [11].

The best results were obtained for demulsifiers TRS DE 1 and G 50 (fig. 2). The amount of separated water was 94.87 %, after about 2 h for TRS DE 1 respectively 98.65 % after 24 hfor G 50, from the total amount of water present in the emulsion, the emulsion break time being relatively short.

Also, regarding the emulsion stability index, was observed higher values correspond to the same demulsifiers, TRS DE 1 and G 50. For TRS DE 1, the highest value (92.1 %) was obtained and for G 50, the value obtained was 78.6 % (fig. 3).

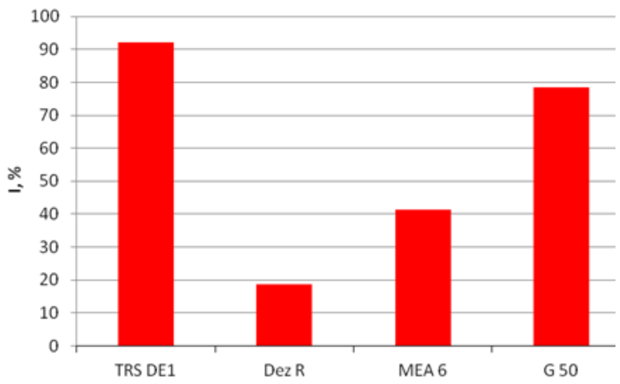

Fig. 3. Emulsion Stability Index values for tested demulsifiers

Based on these results, the demulsifiers TRS DE 1 and G 50 were selected for compatibility testing.

Compatibility tests were carried out between the fracturing fluid and the selected additives, with the emulsion from reservoir rock, following the same procedure as described above. The proposed fracturing fluid is based on the polymer (hydroxypropyl guar) dispersed in water crosslinked with borate [6].

Because the liquid will be pumped in the collector together with propant, in order to generate and sustain

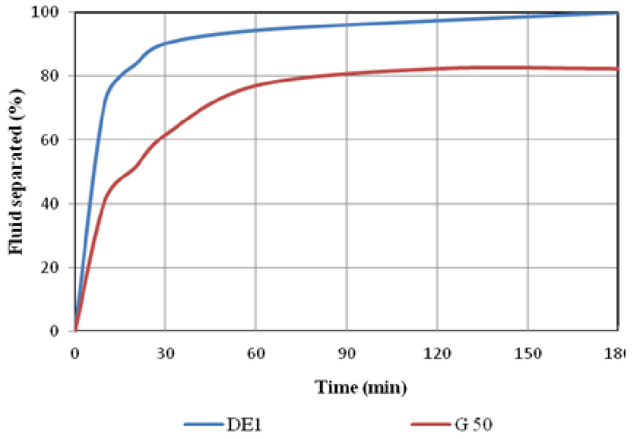

Fig. 4. Compatibility tests between fracturing fluid and emulsioned oil from Well A at 60°C

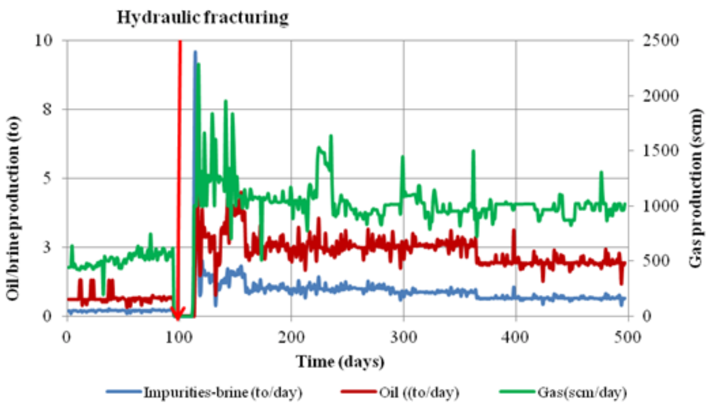

Fig. 5. Well A, productions before and after hydraulic fracturing

cracks, it should contain other additives or chemicals too, that will enable the liquid to be compatible with the reservoir fluids and the porous space. To this end, the fluid will contain: polymer, biocides, emulsion breaker, clay stabilizer, the breaking agent and crosslinking agent. Such fluids have been prepared and tested for cracking additive with the two emulsion breaking agents selected respectively TRS DE 1 and G 50. The results of the tests are shown in figure 4.

It can be seen that the fracturing fluid which was admixed with TRS 1 is more efficient than the fluid admixed with G 50. Thus the total time of emulsion breaking when TRS 1 is used is about 150 min, sufficient to eliminate the possibility of generating an emulsion and to help breaking down emulsified crude oil in the reservoir.

The recipe of fracturing fluid has been applied successfully in well A. In figure 5, the evolutions of oil and gas productions from the well are presented, before, during 100 days as well as after the hydraulic fracturing with emulsion breaking, for 400 days.

It may be noted that before performing hydraulic fracturing process, the net crude oil production was about 0.5 t/day. Compared with the initial production, we can see that net crude oil production increased almost five times and gas production increased nearly two times after the emulsion breaking process associated with hydraulic fracturing.

Conclusions

The objective of the experiments presented in this paper was to achieve the demulsification of crude oil produced by a well, simultaneously with performing a hydraulic fracturing operation. The demulsifier with the best efficiency, compatible with both emulsified crude oil and hydraulic fracturing fluid was identified as a result of the carried out tests. Moreover, the choice accuracy has been proven by the results of well A, after the operation of hydraulic fracturing was performed. It is obvious that these are due to the synergistic effect of diminishing oil viscosity as a result of the demulsifying process on one hand and of the growing flow capacity of the reservoir caused by the fracturing process on the other hand. In other words there has been a significant increase of the fluids' mobility from the reservoir leading to a corresponding increase in the productivity of the well. This increase, as can be seen, took place over a long period of time, surpassing the monitoring period of 400 days.

Given the success of the treatment to which well A was subjected, it can be concluded that it may be expanded to other wells on the oil field also.

Moreover, the described methodology for determining the fluid's recipe to be used in a specific case of emulsion breaking and hydraulic fracturing can be used for any other similar situation.

References

1.SCHRAMM, L.L. Petroleum Emulsion: Basic Principles - Fundamentals and Applications in the Petroleum Industry, Advances in Chemistry Series-231: Washington DC, **1992,** p. 1, 5, 98, 313

2.STOICESCU, M., CRISTESCU, T., Rev. Chim. (Bucharest), **59**, no. 8, 2008, p. 906

3.KOKAL, S.L., Crude-Oil Emulsions: A State-of-the Art Review, February, SPE, Production & Facilities, **2005,** p. 5-13

4.KOKAL, S.L., Crude-Oil Emulsions: Petroleum Engineering Handbook, SPE, Richardson, Texas, **2005,** Vol. 1, Ch. 12, p. 553

5.GHETIU, I., STAN, I.G., PANAITESCU, C., JINESCU, C., MARES, A.M., Rev. Chim. (Bucharest), **68**, no. 2, 2017, p. 273.

6. TAMAS, A., PADURE, M., VINCZE, M., Rev. Chim. (Bucharest), **67**, no. 2, 2016, p. 344.

7.VLADIMIR ALVARADO, V., WANG, X., MORADI, M., Stability Proxies for Water-in-Oil Emulsions and Implications in Aqueous-based Enhanced Oil Recovery, Energies, **2011,** 4, 1058-1086; doi:10.3390/en4071058

8. OLARASU, D.L., STOICESCU, M., Emulsions - a Chalenge in Oil Industry (r), The 10th International Conference on Colloids and Surfaces Chemistry, Galati, Romania, June 9 - 11, **2011**, p. 45

9. HAJIVAND, P., VAZIRI, A., Optimization of Demulsifier Formulation for Separation of Water from Crude Oil Emulsions, Braz. J. Chem. Eng. vol. 32, no.1, **2015**, p. 107

10.BACKER, J.R., Crude Oil Waxes, Emulsion, and Asphaltenes, 11J edition, PennWell, Tulsa OK, **1997**

11.N. MOLLAKHALILI, MEYBODI, N., MOHAMMADIFAR, M.A., ABDOLMALEKI, K.H., Journal of Food Quality and Hazards Control, 1, **2014**, p. 102.

Manuscript received: 21.01.2018