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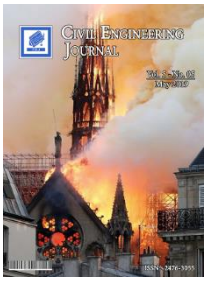
Civil Engineering Journal

Vol. 5, No. 5, May, 2019



Research of Scale Inhibitors in Downhole Equipment

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Received 02 March 2019; Accepted 20 May 2019

Abstract

The article is devoted to the problem of salt deposition in the West-Agan field of Western Siberia in various types of oil equipment during the extraction and transportation of petroleum products, as well as research and identification of the most effective inhibitors. The article is devoted to the problem of salt deposits in various types of oil equipment during the extraction and transportation of petroleum products. Salinity (scale) adversely affects the surface of pipes, the working parts of pumps, installations in contact with formation waters. When this occurs, the parts are jammed or break. The article describes methods for solving the problem of scaling using inhibitors. The possibility of SIs supplying in the reservoir with the aim of its subsequent removal in the composition of the reservoir fluid [1-4]. The data on the adsorption-desorption capacity of scale inhibitors on core samples were studied. Adsorption was tested under dynamic conditions on the FDS-210 filtration unit, filled with a core from the West Agan field. The core was saturated with a scale inhibitor through pumping a 1% solution through it. Desorption of inhibitors was modeled by passing the bottom-water model through the cell under the same pumping conditions. The results of processing the experimental data are obtained; the figures are shown in the form of the dependence of the Freundlich equation relating the magnitude of adsorption to the current concentration of inhibitors, as well as the profile of the removal of Descum-2 scale inhibitors H-3611-Descum-4 and OEDPK. The paper presents the results of modeling the removal of Descum-2 inhibitors of the mark H-3611-A, Descum-4 of the mark S and OEDFC in the form of a table. The use of the studied inhibitors on the West Agan field allows to increase the duration of the maintenance-free period of the well equipment.

Keywords: Adsorption-Desorption Capacity; Core; Inhibitors; Field Test; Productive Stratum; Scaling.

1. Introduction

Complications associated with the development of oil and gas wells, are an aggressive component of inorganic salts of various types. These deposits disable ground valves, tubing, electrical centrifugal and piston pumps, production string and field equipment [5]. These phenomena reduce the efficiency of well pumps, lead to a decrease in the rise of oil and, consequently, to a decrease in well production [6].

This article discusses the results of laboratory studies of scale inhibitors Descum-2 of mark H-3611-A and Descum-4 of mark S for deposits of the Khanty-Mansi Autonomous District. Determination of the adsorption-desorption capacity of inhibitors on core samples of the West Agan field was carried out to assess the ability of inhibitors to effectively protect downhole equipment from scaling when setting the reagent solution into the reservoir. The choice of the reservoir core is due to the need for analysis in the most difficult conditions of fluid passing through the rock. The tests were

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http://dx.doi.org/10.28991/cej-2019-03091321

carried out according to the following methodological and regulatory documents:

- Agreement of the company OJSC "NK "Rosneft"" No. П1-01.05Р-0339 "Procedure for the use of chemical reagents at hydrocarbon production facilities".
- Terms of Reference for laboratory testing of scale inhibitors in producing wells of fields for injection by the method of injection into the reservoir.

Laboratory tests of Descum-2 scale inhibitors of mark H-3611-A and Descum-4 mark S were carried out in the accredited laboratory of OJSC NizhnevartovskNIPIneft (Accreditation certificate ROSS RU00001.21NK28).

The customer handed over samples of scale inhibitors Descum-2 of mark H-3611-A, Descum-4 of mark S with a volume of 1 liter each, manufactured in accordance with TU 20.59.42-126-94296805-2017 and TU 20.59.42-127-94296805-2017, documentation on these inhibitors and the terms of reference for laboratory testing.

The innovation of this article is the laboratory testing of the above inhibitors and the research of the reagent in order to comply with the requirements of the regulatory documents of Rosneft for the application of pilot tests for the protection of borehole equipment from scaling.

2. Research Methodology

In the process of studying the problem of scaling is the use of scale inhibitors (ISO). Salt deposits in the oil and gas sector have a detrimental effect on oil production, which is a very difficult problem in the development and exploitation of oil fields. Huge money is spent to restore and replace oilfield equipment due to scaling every year. In order to combat salt formation, the oil workers use inhibitor protection.

Many of the world's scientists are tackling this problem: Mike Crabtree from Aberdeen, Scotland, David Eslinger from Tusla, Oklahoma, USA, Phil Fletcher and Matt Miller from Sugar Land, Texas USA, Ashley Johnson from Rosharon, Texas, George King from BP Amoco Corporation Houston, Texas and many others. Russian scientists are also studying this problem: Korobeinikova DS, Sibiryakov KA, Tarkhov L.G. (Perm), A.N. Semenov, D.V. Markelov (LLC Yuganskneftegaz), V.V. Ragulin, A.I. Voloshin, A.G. Mikhailov (YuNG-NTTs Ufa LLC), Kanzafarov F.Ya. (LLC NizhnevartovskNIPIneft). After analyzing the work of the authors, we concluded that the use of scale inhibitors, such as Descum-2 mark H-3611-A and Descum-4 mark S for the fields of the Khanty-Mansi Autonomous Okrug were not investigated.

This paper is the result of works on laboratory modeling of scale inhibitors, such as Descum-2 mark H-3611-A and Descum-4 mark S for fields of the Khanty-Mansi Autonomous Okrug. The possibility of supplying scale inhibitors to the reservoir for the purpose of its subsequent removal as part of the formation fluid was considered in the course of our study.

The studies were carried out on a filtration unit FDS-210, filled with the core of the West Aganskoye field using the following algorithm. Initially, inhibitors were fed into the core holder in saline water with disintegrated rock. The filtration rate of fluid through the rock was 1.5 m / day. The core was saturated with a scale inhibitor by pumping a 1% inhibitor solution through the core. At the output of the core holder, 3 ml of solution was selected, which was analyzed for the content of the active substance of the commercial form of scale inhibitors. To determine the content of phosphonates in solutions, a standard technique was applied (the photometric method for determining the concentration of phosphorus-containing inhibitors of salt formation in saline water is based on the reaction of the interaction of phosphate ions obtained from phosphonate with molybdate ion in an acidic medium). The concentration of inhibitors was determined by calibration straight. After passing 10 pore volumes through the porous medium and reaching the concentration of inhibitors in the outgoing solution corresponding to the initial concentration, the dosing of the inhibitors was stopped, and the core with the inhibitor was kept for 2 hours to adsorb the reagent on the rock.

Desorption of inhibitors was carried out by produced commercial water through the cell. Pumping modes have not changed. At the outlet of the column, 3 ml of the working solution is selected, which was analyzed for the content of scale inhibitors. After passing about 30 pore volumes and reaching the concentration of the active substance in the solution corresponding to the detection threshold (~ 1 mg/l), the experiment was stopped. The obtained inhibitor removal curves were processed using the Squeeze V software package, the "ADSORPTION ISOTHERM DERIVATION MODEL" subroutine. The initial data for this subprogram are the results of the removal of scaling inhibitors: the dependence of the concentration on the volume of the pumped liquid, expressed both in absolute units and in the number of pore volumes.

The results of processing the data obtained are shown graphically in Figure 1 as a dependence of the Freundlich equation relating the magnitude of adsorption to the current concentration of inhibitors. In the course of work, methods of laboratory research, analytical character were used; software (Squeeze V program) was used by applying test simulation of the process.

In the process of oil production in various elements of the oilfield system, inorganic salts may be deposited from the formation waters [7]. Salt formation is noted in wellhead equipment, discharge lines of wells, metering installations; However, most often this process takes place in production wells, which leads to deposition on working parts and surfaces of ESP, as well as other hydraulic machines, dense, stone sediment of 0.5-1.0 mm thick [8].

The heat exchange is disturbed because of sedimentation, the impellers of the pump unit become jammed and the shaft breaks [9]. Such complications inevitably lead to the appearance of premature failures of the underground equipment of pumping wells; as a result, there is a decrease in the work of the well during the turnaround time, and therefore a drop in oil production occurs [10].

In the fields of Western Siberia, calcium carbonate is the main component of solid deposits. In addition to $CaCO_3$, silica (SiO_2), corrosion products ($FeCO_3$), and hydrocarbons are found in the composition of the deposits [11].

In oil field practice, one of the main methods of controlling salt deposits is the use of scale inhibitors. Various technologies are used to supply scale inhibitors to production wells. In this paper, we consider the possibility of supplying scale inhibitors to the reservoir with a view to its subsequent removal as part of the formation fluid. To implement this technology, data on the adsorption-desorption ability of scale inhibitors on core samples are needed [12].

In the study of scale inhibitors of downhole equipment, adsorption under dynamic conditions was studied on a filtration unit FDS-210, filled with a core of the West Agan field. Solutions of inhibitors in saline water were fed to the core holder with disintegrated rock. Cell size 30x30. The linear filtration rate of the fluid through the rock was 1.5 m / day.

In the study of desorption of inhibitors, produced water was passed through the model cell [13], under the same pumping regimes. The solution at the outlet of the cell was analyzed for the content of scale inhibitors. The results of the experiment were processed using the Squeeze V software complex and obtained in the form of curves of inhibitor removal lines. The study of adsorption-desorption properties was carried out for scale inhibitors under the trade names Descum-2 and Descum-4, using the HEDP inhibitor as the base of comparison.

The results of processing the data obtained are shown in Figure 1 as a dependence of the Freundlich equation relating the magnitude of adsorption to the current concentration of inhibitors [14].

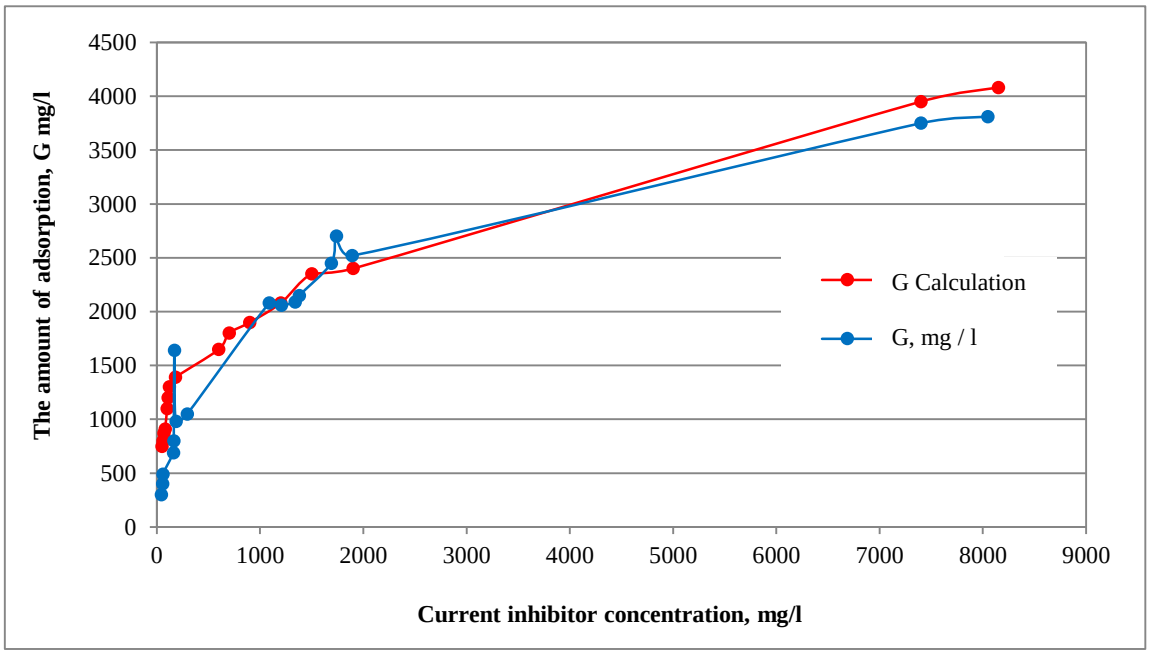

Figure 1. Adsorption isotherm of Descum-2 inhibitors of mark H-3611-A, Descum-4 of mark S on the core rocks of the West Agan deposit

According to the testing of the adsorption-desorption properties of 10% solutions of salt-inhibitors Descum-2 mark H-3611-A, Descum-4 marks S and 10% solution of scale inhibitors HEDP for comparison, test simulations of the squeeze were performed (Squeeze V program) with given volumes the main commissioning of 10 m 10% solution of inhibitors and the displacement of 25 m^3 for a well with a flow rate of 60 m^3 / day. As a result, the profile of the exported concentration of inhibitors (Figure 2) and the time of removal of the inhibitors to a given final concentration (10 and 5 mg/l) were determined.

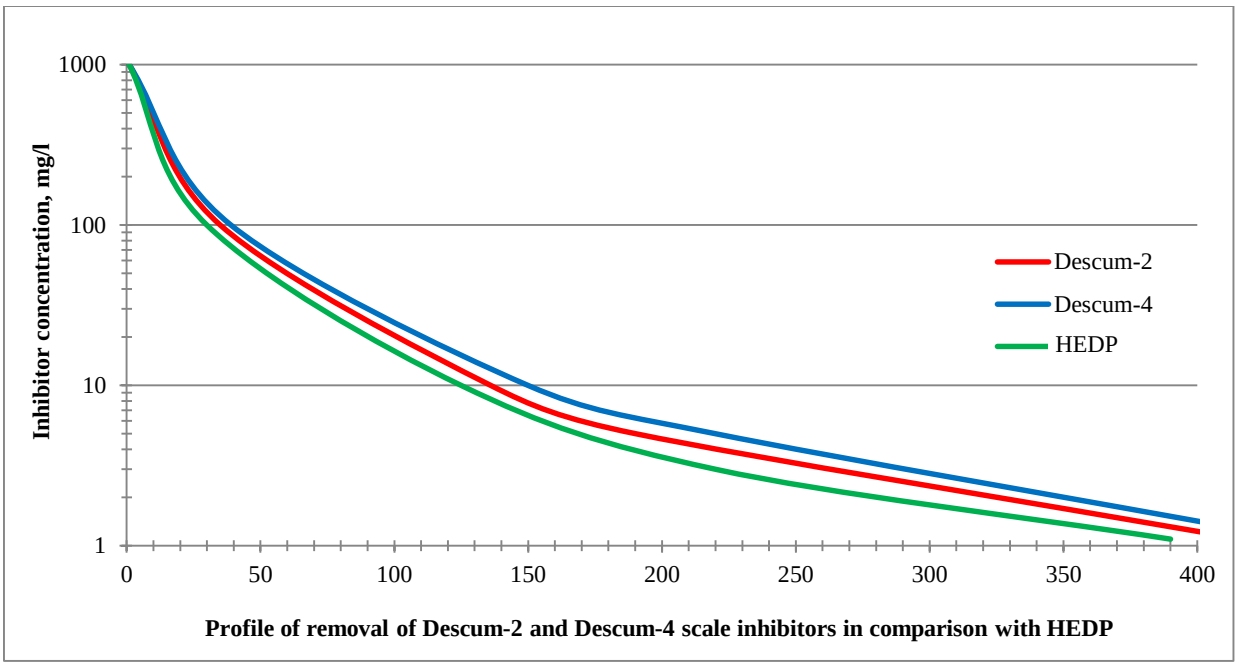

Figure 2. Profile of the removal of scale inhibitors Descum-2 mark H-3611-A Descum-4 and HEDP

These parameters are recommended to be used to simulate the injection of inhibitor solutions into the reservoir (squeezetreatment), the time of well protection and the calculation of the necessary volumes of the main pump and slip (technology design).

The results of modeling the time of removal of inhibitors to achieve concentrations of 10 and 5 mg/l are presented in Table 1.

Table 1. The simulation results of the removal of Descum-2 inhibitors, mark H-3611-A, Descum-4, mark S and HEDP

Inhibitor	The time to reduce concentration, day	
	Up to 10 mg/l	Up to 5 mg/l
Descum-4 Mark S	152	305
Descum-2 mark H-3611-A	143	270
HEDP	125	230

Considering that the minimum operating concentration for HEDP is 10 mg/l, and for Descum - S5 mg/l, the protection time of the well with the given parameters is 152 and 305 days, and for Descum-2, H-3611-A 5 mg/l protection time of the well with the given parameters is 143 and 270 days, respectively. By optimizing the volumes of displacement and the volume of crushed scale inhibitors Descum-2, mark H-3611-A and Descum-4, mark S, the difference in removal time can be reduced or corrected according to the results of field tests.

2. Results and Discussion

It was established that 10% solution with Descum-2 reagent H-3611-A and Descum-4 reagent S in the amount of 0.5 m^3 per 1 m^3 of daily production of water should be pumped for the organization of scaling protection with Descum-2 reagent of mark H-3611-A and Descum-4 reagent of mark S, using the injection method within 365 days with the expected reagent removal of at least 10 g/m^3. After selecting a well and calculating the number of inhibitors, 50 m^3 of bottom-water is pumped into the formation.

In this article, the input control and laboratory tests of Descum-2 inhibitors of mark H-3611-A and Descum-4 of mark S, produced by LLC Mirriko, were carried out, which showed that:

- Samples of the reagent were input control and correspond to the indicators stated in the specifications and passport for the party [15].
- The properties of Descum-2 inhibitors H-3611-A and Descum-4 S-mark correspond to the set of requirements of the regulatory documents of Rosneft for admission to pilot tests.
- The reagent is provided with a full package of permits.

Based on the aggregate results of the analysis, the reagent can be recommended for pilot testing for the protection of borehole equipment from scaling by the method of injection into the reservoir, as well as to simulate the injection of inhibitor solutions into the reservoir (squeezetreatment), time of well protection and calculation of the required back pressure and displacement (design technology).

Recommendations on the use of inhibitors are given.

To calculate the total amount (in m^3) of Descum-2 reagents, mark H-3611-A and Descum-4, mark S, for conducting pilot tests for 365 days using the injection method with the expected reagent removal of at least 10 g/m^3, volume of daily water flow rate of the selected well should be multiplied by 65 (50 l – the volume of 100% Descum-2 reagent of mark H-3611-A and Descum-4 of mark S + 30% loss in the reservoir).

3. Conclusion

Thus, this study of various scale inhibitors confirms their useful properties, the use of which prevents premature wear, increases the overhaul period, as well as the duration of uninterrupted operation of downhole equipment. The results suggest that this study is relevant and appropriate and has a practical application of the studied ISO in the West Agan field of Western Siberia.

4. Conflicts of Interest

The authors declare no conflict of interest.

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