Evaluation of the effect of asphalt resin paraffin deposits on oil well performance

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Abstract. The article deals with the problems of field development. The causes of low well performance were identified. Examples and causes of paraffin deposit formation were given. Methods aimed at solving problems of well operation were developed. An innovative method for dealing with asphalt-resin-paraffin deposits was suggested. It involves application of a submersible container with a complex action inhibitor. The formula of the inhibitor is presented. The technological layout of the container with the inhibitor is presented. Technological efficiency of the inhibitor as a method for ASPD prevention was proved.

1. Introduction
The Russian Federation has enormous reserves of raw materials and energy resources. They are about 80 million barrels which corresponds to 5% of the world reserves. Russia produces a huge amount of coal, natural gas, gold, platinum and other minerals and occupies one of the leading positions in oil production. As of 2019, Russia ranks 8th in the list of the countries with the largest oil reserves [1-3]. Every year, the Russian Federation produces over 500 million tons of oil which is an impressive indicator in the oil industry. Currently, the oil industry is actively developing in the regions of the Russian Federation, especially in Western Siberia. Today, over 70% of Russian oil is produced there [1, 4].

2. Methods and materials
The paper deals the most important issues arising during the operation of an ESP system: these are problems preventing the oil industry from stable production.
If there are complications, it makes no sense to talk about well performance, there is a decrease in the volume of oil production and economic indicators. To maintain oil well performance, various measures have to be taken.

3. Results and discussion
Leading oil companies are interested in increasing profit and reducing production cost. For these purposes, operation of oil equipment has to be failure-free.
Unfortunately, operation of wells of the Fainskoye field is rather problematic. The main causes are of technological or geological nature.
In recent years, there has been a decrease in the annual volume of oil production. Currently, the volume is equal to 2.9 million tons, while water injection is equal to 3.5 million m³ [5]. A decrease in
production volumes is due to a decreasing amount of developed reserves and decreasing productivity of drilled areas.

The decline is due to premature failure of the plants caused by technical problems: inappropriate capacity of the electric centrifugal pump (ESP), poor sealing of pump-compressor pipes (PCPs). The depth of the ESP is also important.

From a geological point of view, well operation leads to formation of paraffin and salt deposits. Contamination of the wellbore zone (WZ) also plays an important role for the operation of wells. Contamination with sand, corrosion products and salts decreases well performance [6].

Oil in reservoir conditions is in the thermodynamic equilibrium. During the oil production, this thermodynamic equilibrium is disturbed due to the transition of oil from reservoir conditions to the surface ones. During this transition, hydrocarbon gases, paraffin, resins and asphaltenes release from the complex mixture of different hydrocarbons. These substances are deposited on the inner surfaces of the pipes and impede fluid flow. Therefore, the main type of complications is formation of asphalt-resin-paraffin deposits (ARPDs) [7, 8].

Methods for dealing with ARPDs can be divided into two groups (Figure 1).

Epoxies, glass and enamels are used for smooth coatings. They are applied on the inside of the tubing where pipes are in direct contact with the fluid. These coatings can reduce the flow resistance by 20-30 % [3, 4].

Chemical methods for preventing ARPDs include the use of dispersants (do not allow heavy hydrocarbons to adhere to the pipeline walls), depressants (reduce oil viscosity) and modifiers (change properties of the reservoir fluid).

Scratchalizers, punchers and other scrapers are used to prevent ARPDs formation.

Thermal methods are as follows: heated steam, hot oil or water, electric or induction heaters. The use of complex reagents is optimal. Most of the existing chemical methods are widely used in the oil industry [9].

The reagents of complex action have a multifunctional effect. When using these reagents, deposition of asphaltenes, resins and paraffins, corrosion processes and deposits of mineral salts can be prevented at the point where borehole products contact with the surface of pipes and pumps.

Solid reagents are placed in the container (Figure 2) whose length varies from 10 to 25 m and brought down to the predetermined depth below the electric centrifugal pump. Downhole products gradually dissolve the reagent and the flow is treated.

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**Figure 1.** ARPDs control methods.
The inhibitor is a mixture of solvent and additives. The solvent consists of alcohol and hydrocarbon compounds, and the additives consist of quaternary ammonium salt of alkylimidazoline vegetable oil and benzyl chloride (Figure 3). The following ratios of the mixture components are used: solvent - 70-99%, additive - 1-30%.

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\text{CH}_2\text{C}_6\text{H}_5
\]

\[
[\text{R-C=N-C}_2\text{H}_4-\text{N-C}_2\text{H}_4-\text{OH}]^+\text{Cl}^-
\]

Figure 3. Formula of the complex use inhibitor.

The use of complex reagents for wells provides an effective influence on the flow of well products. The effect of the reagent lasts for more than three hundred days [10]. The effect was confirmed by a number of wells in the Fainskoye field where containers with complex reagents were installed. The results of the measures are presented in Table 1. In all the wells, paraffin deposits, corrosion, and wear of well equipment decreased. The well overhaul period increased several times [10–11].

Table 1. The influence of complex use reagents on the well repair interval.

| No. of the well | Type of problems          | Before the running RI, days | After the running RI, days |
|-----------------|---------------------------|-----------------------------|----------------------------|
| 1               | Salt deposition, Emulsion | 145                         | 930                        |
| 2               | Corrosion                 | 200                         | 854                        |
| 3               | Corrosion, emulsion       | 125                         | 659                        |
| 4               | Salt deposition           | 186                         | 895                        |

4. Conclusion

In order to occupy a leading position by the volume of oil production, the Russian oil companies have to ensure failure-free operation of their wells. For these purposes, capsules with complex reagents should be used. The effectiveness of this method was proved by a number of wells in the Fainskoye field.
The following conclusions can be drawn:

1) to achieve the best results, methods for asphalt-resin-paraffin deposit formation prevention can be used;
2) to obtain the maximum result when using complex-effect reagents, it is necessary to follow the change in the technological mode of well operation, in particular, an increase in the water-cut of well products;
3) before installing containers, it is necessary to remove ARPD from oil equipment.

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