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Research on High-Viscosity Oil of the Zyuzeyevskoye Field to Select the Controlling Method for Asphaltene, Resin, and Paraffin Substances Deposition in Oil Production

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Abstract The paper considers the current views on the government deposits of asphaltene, resin, and paraffin substances in oilfield equipment and possible solutions to this issue. The authors introduce classification and choose the most effective solvent to determine the optimal method for controlling sediments. The solutions of each sediment component are analyzed by the conductometric method of dispersion analysis with the help of the Coulter counter particle size analyzer, and there is a comparative evaluation of the sizes and ratios in sediments of various oils. In the various oils of the Zyuzeyevskoye field, the content of resinous-asphaltenic substances is above the critical value of 35 wt%. The decrease in the proportion of resinous-asphaltenic substances in the Vereiskian, Bashkirian, and Tournaisian reservoirs is associated with an increase in the oil-bearing rock age. Branching of paraffinic structures and high condensation of polyaromatic structures affect all production processes and oil treatment and transportation. The paper presents the influence of hydrocarbon composition on the development mechanism, composition, and properties of asphaltene, resin, and paraffin substances. The research demonstrates that in order to select the most effective ways of organic substance sediment prevention and removal from the physical–chemical point of view, one needs to obtain an idea about the composition and the properties of the initial oil and the developed deposits.

Keywords Asphalt and resin paraffin substances · Carbonic oils · Development · Bottom · Hydrocarbons · Composition · Production · Transportation

1 Introduction

With the development of light oils, in just a few years, the basis of the hydrocarbon potential of Tatarstan will be carbonic oils. These oils differ in their basic physicochemical properties and composition [4].

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During oil production, they encounter one of the issues causing the complication in automatic oilfield equipment and further transportation through pipelines. These deposits accumulate in the flowing parts of oilfield equipment and on the inner surface of pipes, which leads to a decrease in oil production and transportation system productivity [2].

Deposits of asphaltene, resin, and paraffin substances (ARP-S) increase the equipment wear, energy costs, and pressure in a system. Currently, this issue is exceptionally urgent for the production and transportation of hydrocarbons. The following factors influence the development of ARP-S:

- Pressure reduction;
- Intensive gas release;
- Temperature drop;
- Composition of hydrocarbons;
- Temperature gradient change.

2 Materials and Methods

The primary method of ARP-S removal is the prevention of deposit development on oilfield equipment, but if the deposits have developed, then the secondary method consists in removing these sediments [3].

ARP-S deposits are formed in a bottom hole zone of a well, on the walls of a wellbore, and oilfield equipment. The authors propose the following methods of prevention and disposal of these sediments:

- The injection of reagents, acids, coextractants, suppressing the development of paraffin bunches during the extraction and the transportation of hydrocarbons into a system;
- The covering of the inside of an oil field equipment with a layer reducing the adhesion of ARP-S to the pipe walls;
- The injection of biodegradable composition into an extracting medium, which prevents the development of ARP-S;
- The installation of electric heaters at a well bottom designed to maintain the temperature above the melting point of paraffin in a well;
- The increase of asphalt-resinous compound percentage;
- The maintenance of constant pressure in the system of oil production equipment at the well bottom;
- The use of exothermic reactions, and, thus, the increase of produced hydrocarbon temperatures at the bottom of a well and the prevention of asphalt-resinous and paraffin deposit development.

One should note that while selecting one or more ARP-S prevention methods or removal, the composition and the properties of hydrocarbons, the percentage ratio of asphaltenes, resins, and paraffin should be considered [1].

Determination of particle size of oil dispersed systems is carried out by conductometric method using the Coulter Counter analyzer of the TA-II model of IDF Production (UK). The determination of dispersity by the conductometric method is based on measuring the electrical resistance at the moment when the particles pass through the calibrated micro-holes.

The working apertures (tubes) of different diameters are used to determine the particle size of the disperse system. The working volume of the sample is 0.5 ml.

The research uses the method of IR spectroscopy to analyze oils and their components. Furthermore, it evaluates the average molecule of the studied objects based on spectral coefficients.

3 Results

The research object is the high-viscosity oil of the Zyuzeyevskoye field. A feature of this field is the production of carbonic (high-viscosity) oil, which is characterized by a reduced yield of straight-run light fractions and a high content of sulfur and metals.

Characteristics of Zyuzeyevskoye oil treated in accordance with the requirements of GOST R 51858-2002 are illustrated in the work [4].

The authors select oil samples from four productive reservoirs for the analysis. They include Vereiskian, Baskirian, Bobrikovskian, and Tournaisian.

Table 1 presents the results of the oil composition of individual reservoirs.

By studying the distribution of oil components, one can trace the patterns associated with an increase in the age of oil-bearing rocks represented by carbonate rocks (Vereiskian-Bashkirian-Tournaisian). According to the compositional data for all studied oils, the content of resinous-asphaltenic substances exceeds the critical concentration.

Table 1 The composition of oils of individual reservoirs

Reservoir/stage, well number	Composition, in wt%				
	I. B. – 200 °C[a]	Oils	Benzene resins	Alcohol-benzene resins	Asphaltenes
1	2	3	4	5	6
Vereiskian; 2518	14.9	35.9	37.6	8.3	3.3
Bashkirian; 962	12.6	47.6	27.3	7.6	4.9
Bobrikovskian; 2363	11.5	45.3	29.8	10.2	3.2
Tournaisian; 2325	9.0	46.0	26.2	9.6	9.2

Source Compiled by the authors

[a] *I. B.* initial boiling

Samples of deposits ASP-B of *Tatnefteprom-Zyuzeyevneft JSC* belong to the asphaltene type. For the ASP-B asphaltene type, the most effective solvent is an aromatic solvent [4]. These solvents have an excellent dissolving power concerning asphalt-resinous substances. The nature of the action of the solvent consists in dissolving the resins, which are the binding agent of paraffin agglomerates, and the partial dissolution of asphaltenes, transferring deposits on pipelines into suspended particles that are easily carried away by the flow.

Besides, in the course of this paper, solutions of each component of deposits are analyzed with the Coulter Counter particle size analyzer in order to evaluate the sizes comparatively, their ratios in sediments of various oils. The study results are presented in Tables 2 and 3 and Fig. 1.

The particle sizes are represented as the Poisson distribution in (Fig. 1).

As can be seen from the graphs, there is an almost identical repetition of the curves obtained during the analysis of the group components of various ASP-Bs. From the authors' perspective, this fact allows one to preliminarily conclude that in the investigated sediments, despite the different origin and differences in the group composition, the ASP-B components do not differ in their characteristics from each

Table 2 Particle sizes of ASP-B in the Zyuzeyevskoye oilfield well No. 2321. *Tatnefteprom-Zyuzeyevneft JSC*

Channel range (μm)	% of the total particle number		
	Paraffins	Resins	Asphaltenes
1	2	3	4
1.26–1.59	0	0	0
1.59–2.00	6.7	6.9	7.1
2.00–2.52	8.2	7.9	8.7
2.52–3.17	5.9	6.3	6.3
3.17–4.00	7.5	7.7	7.4
4.00–5.04	6.5	6.3	5.8
5.04–6.35	6.7	6.8	6.8
6.35–8.00	7.9	7.7	7.5
8.00–10.1	4.8	4.3	4.3
10.1–12.7	8.1	7.9	7.7
12.7–16.0	7.1	7	6.8
16.0–20.2	5	5.4	5.3
20.2–25.4	5.9	5.8	5.7
25.4–32	5.3	4.3	5.2
32–40.3	4.9	5	5
40.3–	8	7.9	7.8

Source Compiled by the authors

Table 3 Particle sizes of ASP-B in the Zyuzeevsky deposit borehole. No. 961 of *Tatnefteprom-Zyuzeyevneft JSC*

Channel range (μm)	% of the total particle number		
	Paraffins	Resins	Asphaltenes
1	2	3	4
1.26–1.59	0	0	0
1.59–2.00	6.1	6.8	7.6
2.00–2.52	7.5	7.7	8
2.52–3.17	6.1	6.1	6.2
3.17–4.00	7.5	7.5	7.6
4.00–5.04	6.1	6	6.2
5.04–6.35	6.8	6.7	6.8
6.35–8.00	6.9	7.5	7.6
8.00–10.1	4.3	4.2	4.3
10.1–12.7	7.8	7.6	7.7
12.7–16.0	6.9	6.8	6.8
16.0–20.2	5.9	5.3	5.4
20.2–25.4	5.8	5.6	5.8
25.4–32	6.6	5	4.6
32–40.3	5	5	5
40.3–	8.2	7.8	7.9

Source Compiled by the authors

other. It is possible to assume that the group components have approximately the same molecular mass and structure.

ARP-S development factors. The authors have learned that the thickness of ARP-S deposits depends on the depth (Fig. 2).

Figure 3 depicts asphaltene-resinous and paraffinic deposits.

In the process of analyzing Figs. 2 and 3, one should note that the development of ARP-S on the borehole wall is associated with a temperature drop, thereby making it challenging to extract hydrocarbons from the formation. In addition, dynamics growth does not occur in the oil extraction industry [6].

4 Discussion

The authors introduce classification and choose the most effective solvent to determine the optimal method for controlling sediments. The solutions of each sediment component are analyzed by the conductometric method of dispersion analysis with

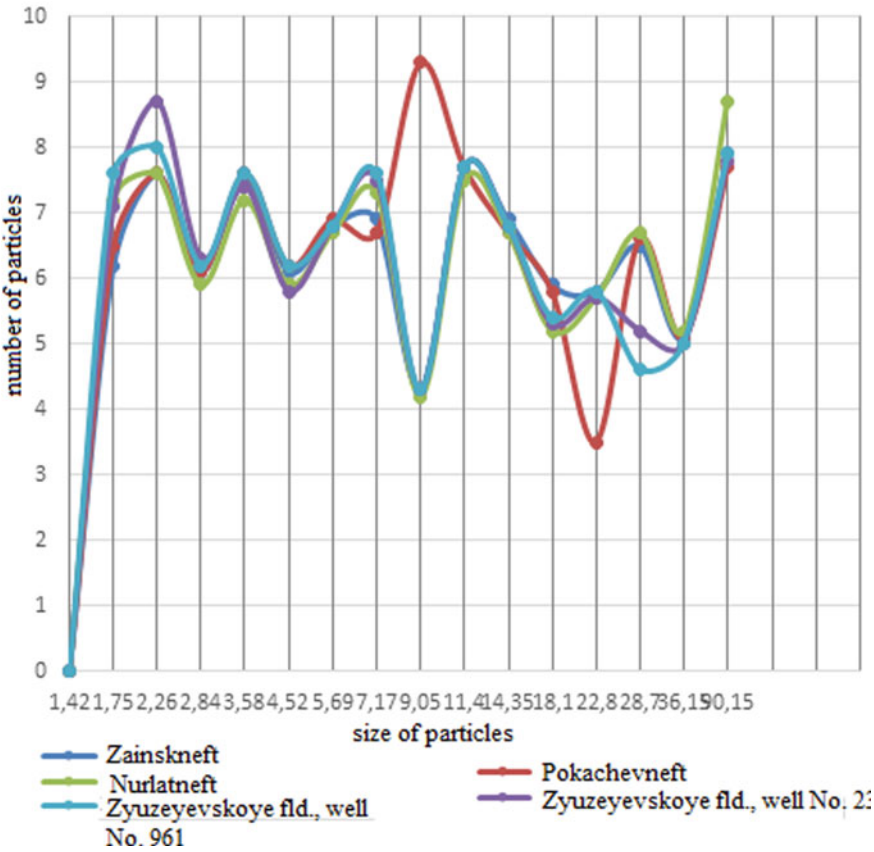

Fig. 1 Poisson distribution of asphaltene particles in a solution of benzene. *Source* Compiled by the authors

the help of the Coulter counter particle size analyzer, and there is a comparative evaluation of the sizes and ratios in sediments of various oils.

Samples of deposits ASP-B of *Tatnefteprom-Zyuzeyevneft JSC* belong to the asphaltene type. For the ASP-B asphaltene type, the most effective solvent is an aromatic solvent. These solvents have an excellent dissolving power with respect to asphalt-resinous substances. The nature of the action of the solvent consists in dissolving the resins, which are the binding agent of paraffin agglomerates, and the partial dissolution of asphaltenes, transferring deposits on pipelines into suspended particles that are easily carried away by the flow.

Based on the research results, one can observe almost the exact repeatability of the curves obtained in analyzing the group components of various ASP-Bs. The research reveals that in the investigated sediments, despite the different origin and differences in the group composition, the ASP-B components do not differ in their

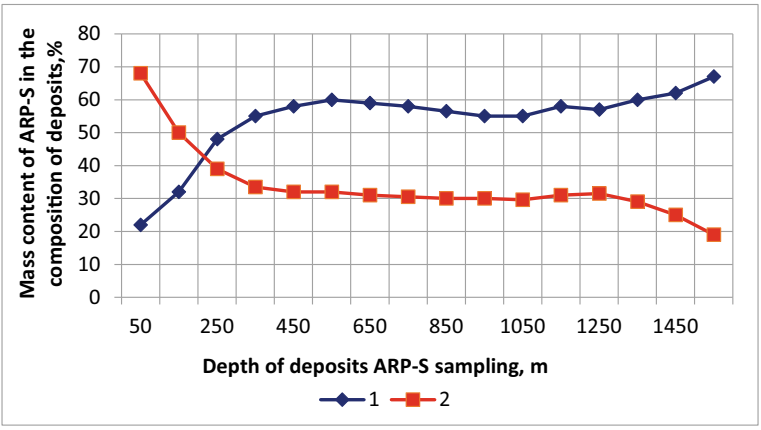

Fig. 2 Dependence of deposit thickness on depth. 1—Paraffins, 2—ARP-S. *Source* Compiled by the authors

Fig. 3 Deposits of asphaltene, resin, and paraffin substances. *Source* Compiled by the authors

characteristics from each other, so it is possible to assume that the group components have approximately the same molecular mass and structure.

In general, in the various oils of the Zyuzeyevskoye field, the content of resinous-asphaltenic substances is above the critical value of 35 wt%. The decrease in the proportion of resinous-asphaltenic substances in the Vereiskian, Bashkirian, and Tournaisian reservoirs is associated with an increase in the oil-bearing rock age. Branching paraffinic structures and high condensation of polyaromatic structures affect all production processes, treatment, and transportation of oil [5].

5 Conclusion

The paper explains the influence of hydrocarbon composition on the ARP-S development mechanism, composition, and properties. The authors also illustrate the methods for removing deposits associated with the use of various additives and reagents and the methods for the prevention of sediment development. The research demonstrates that in order to select the most effective ways of organic substance sediment prevention and removal from the physical–chemical point of view, one needs to obtain an idea about the composition and the properties of the initial oil and the developed deposits.

High-molecular components of oil, namely, their composition, structure, and percentage ratio, have particular importance in many factors that determine the propensity of hydrocarbons to develop asphalt-resinous and paraffinic deposits. Bearing in mind the properties and composition of hydrocarbons, their thermal and hydrodynamic conditions in a productive reservoir, and selecting the methods of fighting with ARP-S properly, one can avoid oilfield equipment and pipeline wear. At one time, this is an economically advantageous condition for the oil and gas industry, which in turn contributes to the reduction of overhaul number and reduced downtime of wells, provides the extension of the equipment life and the rhythmic work of industry, while also reducing the cost of oil production.

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