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PREVENTION OF ASPHALTENE-RESIN-PARAFFIN DEPOSITS IN THE PROCESS OF OIL TRANSPORTATION

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A B S T R A C T

One of the reasons reducing the efficiency of well operation is formation of asphalt-resin-paraffin deposits (ARPD), which are deposited in the bottom-hole zone of wells and on the surface of oilfield equipment. A new inhibitor «NDP-22M» was developed to reduce the solidification temperature of highly paraffinic oils and prevent the formation of asphalt-resin-paraffin deposits (ARPD). In addition to preventing the formation of ARPD, «NDP-22M» significantly improves the rheological properties of highly paraffinic oil, which is important for its further transportation. The reagent reduces the solidification temperature and viscosity of oil, as well as facilitates its fluidity. The inhibitor contains a nonionic surfactant, a depressant agent and a solvent. The prepared inhibitor has the ability to reduce the pour point and viscosity of oil, as well as to prevent ARPD. The prepared inhibitor was studied on oil brought from the wells of the oil and gas production department of the production association «OGPB» (Oil and Qaz Production Board), «Oil Pipeline Administration». In this oil, the amount of paraffin is 10.8%. In the course of research, it was found that the effectiveness of adding 300 g/t of reagent to oil is 75%.

Keywords: inhibitor; paraffin deposits; oil production; dynamic viscosity.

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Introduction

The deposition of wax is one of the most potential problems that disturbs the flow assurance during production processes of hydrocarbon fluids.

In the lifetime of petroleum fields, wax deposition can represent one of the most acute and challenging issues through the production processing parts [1]. Deep water pipelines, offshore and onshore surface facilities such as pipelines and separators are the most exposed parts of the petroleum production chain to the problem of wax deposition [2-4]. Blockage of pipelines and plugging of well bores are among the frequently noticed wax deposition related problems. Therefore, this undesirable phenomenon results in high expenditures and increased technical problems.

Asphaltene-resin-paraffin deposits (ARPD) formed in underground equipment, as well as in flowlines, pipelines and other oil-gathering systems create problems that are constantly encountered in the oil industry. The numerous methods currently proposed to prevent ARPD formation, both physical and chemical, make it possible to increase overhaul period, but it is not possible to completely avoid deposit formation [5].

The layer maintains a sufficiently high temperature to dissolve heavy oil components. As oil rises through the wellbore, the temperature gradually decreases. When the temperature of crude oil drops below the wax formation temperature, wax precipitation occurs When crude oil cools, the first crystals begin to form, this temperature is called the wax formation temperature [6]. Wax can settle and appear when the temperature on the pipe walls is below the wax formation temperature. Precipitation of waxy components from oil leads to changes in the properties of the crude oil, including gel formation and viscosity growth. Wax mainly contains high molecular weight n-paraffin and consists of long chains of alkanes from 20 to 50 carbon atoms [7].

The problem of paraffin deposition is one of the main problems that occurs in the oil and gas industry, as well as during oil transportation. The oil industry loses one hundred million dollars every year monitoring these problems. Waxy paraffin, which are found in crude oil, are organic substances. Paraffin molecules are very complex, have a high molecular weight and contain mainly carbon and hydrogen atoms [8].

ARPD, which are found in the oil industry and affect numerous oil companies around the world, are a major problem in ensuring the flow of crude oil. ARPD impedes the

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flow of crude oil in a pipeline, creating pressure anomalies and causing artificial plugging. This leads to a reduction or even stop of the production process. However, in a worst case, this could result in the pipeline or production facility being inoperable. At the same time, paraffin deposition can also lead to formation damage near the wellbore, reduction of layer permeability and a change in oil composition [9]. There is a certain connection between the composition of the oil, the temperature at which wax appears and the effectiveness of paraffin inhibitors [10].

ARPD formed in underground equipment, as well as in flow lines, pipelines and other oil-gathering systems create problems that are constantly encountered in the oil industry. Currently, the numerous methods are being proposed to prevent ARPD formation, both physical and chemical, allowing to increase overhaul period. However, it is not possible to completely avoid deposit formation [11, 12].

Currently, the content of high-viscosity oils is constantly increasing. Paraffin oils differ by increased value setting point and dynamic viscosity. This fact negatively affects the processes of their production and transportation via pipelines and is therefore a subject for research in order to improve the constructability of the oil industry.

Both nonionic and ionic surfactants were used as surfactants in the compositions of composite surfactant materials (CSM) to prevent paraffin deposition and ARPD [13].

Oil- and water-soluble surfactant- alkylaryl sulfonates and alkaline earth metal naphthenates were used as the latter. Mixtures containing higher aromatic compounds were used as solvents.

Method

As a method for assessing the effectiveness of paraffin deposit inhibitors, we used a method for evaluating the effectiveness of complex action inhibitors developed by SPA «Neftepromkhim» of the Russian Federation [14]. The method is based on determining the technological efficiency of the agents, i.e., assessing the washing of the oil film and the washing of paraffin deposits by the agents.

Determination of film washing is carried out as follows: In a glass test tube half-filled with produced water, oil with agents is added to the level of the test tube. The mixture is allowed to settle for 30 minutes, after which the test tubes are turned over along with the timer starting. Oil and water exchange volumes. The wash area of the surface of the test tube occupied by water instead of oil is recorded. The result is considered excellent if 70% of the area is washed in 30 s, good if within 60 s and satisfactory if within 180 s.

Washing of paraffin deposits involves the following indicators: characterization of the inhibitor emulsion with water, assessment of the area of paraffin deposits on the walls of the metal rod. Moreover, if 5% of the surface is covered with paraffin, then the result is considered excellent, 10% coverage indicates a good result, 40% is considered satisfactory. The amount of dispersion of paraffin deposits is estimated as follows: 0.1-1.0 mm - excellent; 0.1-3 mm is good; 0.1-5 mm is satisfactory.

The particle dispersion size and the washing of paraffin deposits are determined in a conical flask containing produced water, paraffin deposits and an inhibitor dosed at a given concentration. The contents are heated until the paraffin melts to a temperature of 40-60 °C, then cooled while stirring.

After cooling to a temperature of 20-25 °C, the particle size of the paraffin dispersion is measured. Measurements are made under a microscope using a ruler or graph paper. Then, the surface area of the rod, cleaned from paraffin, is measured.

To determine the possibility of using composite surfactant materials (CSM) of the NDP brand as ARPD removers, the above-mentioned agents were tested during washing off an oil film. The results are shown in table 1-2.

As can be seen from the data obtained in table 1, NDP type inhibitors are 50% solutions based on a mixture of various surfactants dissolved in an aromatic solvent.

Table 1
Composition and effectiveness of NDP brand CSM as paraffin deposit inhibitors

CSM brand	CSM composition, %			Paraffin deposit, % mas	Paraffin dispersion value,mm
	surfactant nonionogenic	surfactant ionogenic	Solvent		
NDP-1	20	30	50	3.0	0.1-1
NDP -2	40	10	50	5.0	0.1-1
NDP -3	30	20	50	10.0	0.1-3
SNPX -2005				18.8	0.2-5

Table 2
Washing off asphaltene sediments film with NDP brand agents

CSM dosage, y/t oil	250		200		100	
ARPD wash off, %	70	100	70	100	70	100
Wash off time, sec						
NDP-1	1	3	2	5	5	7
NDP-2	3	5	4	7	3	10
NDP-3	7	13	10	16	15	25
SNPX-2005	0	25	18	30	26	70

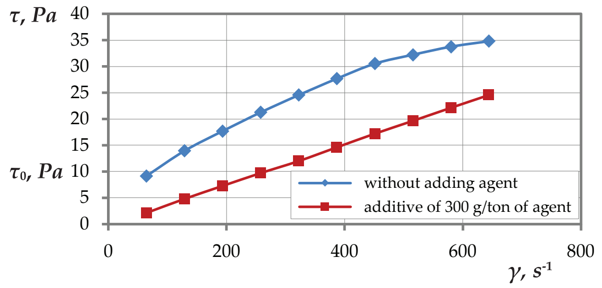

Fig. Dependence of shear stress on velocity gradient

Table 3 Physicochemical characteristics of oils transported via oil pipelines		
Oil Parameters	**OGPB named after N.Narimanov**	**Shirvan Oil**
Density at 20 °C, kg/m³	827.3	895.5
Kinematic viscosity at 20 °C, mm²/s	124.8	270.50
Pour point, °C	+15	+15

The dosage selection was carried out by repeated trials of effective concentrations of the agent. In this case, the optimal dosage was 300 g/t of oil.

Results

As the research results indicate, that the best results in deposition of paraffin were established for oil-soluble samples NDP-1 and NDP-2. However, the dispersion of paraffin for oil-water-soluble analogues is slightly higher. The studied CSM also demonstrate high efficiency as ARPD removers, especially oil-soluble ones compared with the SNPX -2005 brand produced in Russia. Thus, the fundamental possibility of using the proposed NDP brand CSM as paraffin deposit inhibitors and asphaltene sediments removers in systems for the production, storage and transportation of high-viscosity oils has been demonstrated. It should be noted that based on mixtures of NDP-1 and NDP-2, NDP-22M was created, consisting of a blend of non-ionic and ionic surfactants in proportions of 60% and 40%, respectively, and an aromatic solvent. It is known that oils containing ARPD are heterogeneous liquids in terms of their rheological properties. In recent years, one of the main factors in the oil industry leading to complications in oilfield equipment is pressure increase, pipes sticking and a decreased productivity resulting from the deposition of ARPD and a decrease in the cross-sectional area of pipes. This ultimately leads to overhaul period (OHP) increase of production wells and increased costs of their maintenance.

To eliminate the above negative complications, the rheology of the agent NDP-22M, intended to prevent deposits of ARPD, was studied.

For this purpose, the rheological parameters of oil sample taken from Oil and Qaz Production Board (OGPB) «Neft Dashları» were studied in a rotational viscometer of «Reolab QC» (AntonPaar) brand at 40 °C temperature, and without adding agent. During the research, it was found that the oil sample has viscoplastic properties. From the rheological properties of oil with viscoplastic properties, it is known that to remove such oil from equilibrium state, the shear stress τ must be greater than the initial or static shear stress τ_o. Otherwise, i.e. under the condition $\tau \leq \tau_o$, the liquid will be stationary.

In subsequent studies, by adding 300 g/t of the NDP-22M agent to oil sample, the dependence of shear stress on the velocity gradient at 40 °C temperature was studied. The results obtained are presented in the figure.

It can be seen from the figure that after adding the NDP-22M agent in the amount of 300 g/t to the oil, a partial breakdown of the structure is observed at low shear rates, but it becomes more intense at high shear rates. Gradually, the viscosity of the oil decreases, resulting in improved flowability. Apparently, the addition of the NDP-22M agent to the oil changes its rheological and physico-chemical properties. Under agent influence, the structure begins to collapse due to a violation of the equilibrium state of the oil and a change in the shear rate. As a result, oil becomes balanced. The addition of the NDP-22M agent to paraffin oils prevents the formation of crystalline structures of asphaltene sediments. Consequently, the NDP-22M agent, reducing the imbalance coefficient of the system, also causes a change in rheological parameters in a positive direction.

This paper discusses various oils pumped via process pipelines. The purpose of the paper is to improve the physical and chemical parameters of oils transported via pipelines. Some physical and chemical characteristics of oils transported via the above oil pipelines are given in table 3.

Table 4

Research results

Pipeline definition	**Agent brand**	**Dosaging of agent g/t**	**Oil Pour point °C**	**Oil viscosity at 20 °C**		**Oil density kg/m**	**Note**
				Dynamic mPa·c	**Kinematic mm²/c**		
OGPB named after N.Narimanov	-	-	+15	124.8	150.7	827.8	sm
	NDP-22M	300	-17	8.580	10.319	825.6	tl
	SNPX-2005	300	-13	18.440	22.182	827.0	tl
Shirvan Oil	-	-	+15	230.50	258.70	895.5	sm
	NDP-22M	300	-10	55.313	62.072	891.1	tl
	SNPX-2005	300	-9	81.659	91.008	893.0	lv

**sm –slow-moving ; tl – thin liquid ; lv - fluent*

As can be seen from the data in table 3, oil transported OGPB named after N. Narimanov and Shirvan Oil pipelines have an oil pour point at positive temperatures of at least plus 15 °C. Kinematic viscosity at 20 °C temperature for Shirvan Oil is no less than 230.5 mm^2/s, and for OGPB named after N. Narimanov it is no less than 124.8 mm^2/s. As noted above, CSM NDP-22M brand is multifunctional and its use as inhibitor of paraffin deposition in oil fields with a high content of paraffin and asphaltene sediments in the composition of produced oil has shown that at a dosage of 300 g/t of oil transported via pipelines, the pour point of oil is significantly reduced and the kinematic viscosity of oil decreases, which leads to an improvement in their transportation in general. Moreover, this agent prevents ARPD in pipelines by at least 75%. Another an equally effective agent is SNPX -2005. The results of the study are presented in table. 4.

Conclusions

As can be seen from the data in table 4, NDP-22M and SNPX -2005 agents significantly affect the rheological parameters of oils from the OGPB named after N. Narimanov and Shirvan Oil pipelines. According to the research results, the the addition of a agent leads to significant reduction in the pour point of oil. At the same time, there is also a significant decrease both in the dynamic and kinematic viscosities of oil, resulting in enhanced fluidity and mobility.

CSM under NDP-22M brand were developed as a depressant, paraffin inhibitor and remover of asphaltene sediments in systems for production, storage and transportation of high-viscosity oils that solidify at high temperatures. It has been found out that the newly developed NDP-22M significantly outperforms the previously known analogue SNPX-2005, both in technological and operational properties.

The NDP-22M agent can be recommended as an inhibitor to improve the flowability of high-viscosity oils during transportation via oil pipelines.

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