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DEVELOPMENT OF A NEW REAGENT FOR THE PREVENTION OF ASPHALTENE-RESİN-PARAFFİN DEPOSİTS

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ABSTRACT

Asphaltene-Resin-Paraffin deposits (ARPD) form a certain proportion of the crude oil mass, separating as temperature and pressure decrease and adsorbing to the surfaces of the reservoir wellbore zone, downhole equipment and tubulars. These deposits precipitate in the wellbore zone, oilfield equipment and pipes,resulting in reduced system productivity, reduced pumping efficiency of the pumping equipment and other negative consequences. Asphalt-resin and paraffin deposits (ARPD) are a complex mixture of solid paraffin hydrocarbons, asphalt-resin substances (ARS), water and mechanical impurities. The strength and composition of ARPD depend on the composition and properties of oil, geological, physical and technological conditions of field development. Chemical methods for removing deposits are currently the most widely used, as they are highly effective and technologically advanced. To this end, new reagents have been developed and their physico-chemical properties have been studied. Subsequently, the selected reagents were tested on oil samples from Oil and Gas Production Department (OGPD) with a paraffin content of more than 6 %. It was also shown that paraffin inhibitors have individual effects; a reagent that is effective on oil from one field may not have the same effect on oil from other fields. The research includes studies of selected reagents for paraffinic oils from different fields. Using the «cold finger» method, the efficacy of the selected reagents against paraffin deposition was investigated and their optimum doses were determined.

KEYWORDS:
Reagent;
Sendiment;
Paraffin;
Asphaltene;
Resin;
Well bottom zone;
Viscosity;
Depressor.

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https://doi.org/10.53404/Sci.Petro.20240100057

Date submitted: 20.02.2024 ***Date accepted: 30.05.2024***

Introduction

The scientific study of oils, which are considered heavy due to their density, is currently one of the main areas of interest. The chemical composition and physical properties of the oil are considered to be the main factors influencing its extraction and subsequent processing. A key chemical characteristic of heavy oils is the high content of asphaltene-resin paraffin (ARP). The concentration of ARP not only increases the density and viscosity of the oil, but also alters its colloidal structure and rheological properties.

The process of asphaltene-resin-paraffin deposits (ARPD) deposition impedes oil flow, increases pressure, and forms plugs in pipelines. At the beginning of the deposition process, ARPD is in a gel-like state and contains solid paraffin and absorbed liquid. Over time, these deposits solidify. The deposition of paraffin in oil changes its properties, gelling occurs, which leads to an increase in viscosity.

The problem of ARPD formation becomes more serious in connection with transition of many fields to the late stage of development. When oil temperature decreases, paraffin precipitation occurs. The temperature at which the first paraffin crystals are formed is called the paraffin appearance temperature.

Along with paraffin, particles of asphaltenes and resins are also deposited on the surface. Sand particles and mechanical impurities, as well as inorganic salts and water, which are suspended in the oil, make these deposits more stable. This complicates the process of cleaning ARPD. In general, the formed deposits reduce oil production, put out of operation equipment, which leads to additional energy and material costs.There are several ways to combat ARPD in oilfield equipment.

ARPD can be prevented or reduced by chemical, mechanical and thermal methods or a combination of these. Among these methods thermal and chemical methods are the most common. In wells, wax deposition occurs at a depth of 900-1500 meters. Prevention of ARPD with the help of heat carriers becomes ineffective, as the action of heat carriers is effective at depths up to 700 meters. This is due to the fact that when moving hot fluid gradually decreases its temperature as a result of heat transfer with the walls of the well and the surrounding wall of the rock. In such cases ARPD control does not give the desired effect, it is necessary to use paraffin deposit inhibitors.

The heavy oils characteristic of Azerbaijan's fields

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form highly dispersed suspensions and mineral mixtures of paraffin crystals. These suspensions exhibit the properties of solid amorphous substances in bulk. They are deposited in the wellbore zone, oilfield equipment and pipelines, leading to reduced system productivity, reduced pumping efficiency and other adverse effects. ARPD in the wellbore zone and on the surfaces of oilfield equipment cause significant operational problems during well production [1, 2]. Paraffin deposits reduce the filtration properties of the reservoir, clog pores, cause equipment wear and reduce the efficiency of pump-compressor tubing. As a result, the production and transportation of oil is significantly hampered. Improving the rheological properties of paraffinic oils can be achieved by improving the scientific understanding of their physico-chemical properties. The study of rheological principles is considered essential for increasing oil production and selecting the most appropriate technologies for transporting, processing and storing such heavy oils [3, 4].

Purpose of the work

The presence of sand particles, mechanical impurities, inorganic salt crystals and water droplets in the oil provides a particular resistance to ARPD on surfaces, making them more difficult to clean. The formation of these deposits not only reduces well production but also leads to equipment failure, increased energy and material consumption and shorter repair intervals.

The refinement and study of the parameters of the paraffin deposition process allows a more objective assessment of the feasibility of applying methods to control these deposits within the oil production system. The problem of paraffin deposition has become critical in most areas of the oil industry and requires a systematic approach to its solution. Modelling the paraffin deposition process facilitates the application of automated control systems in the oil extraction process. The profitability of oil and gas production companies depends on the effectiveness of the technological processes used and the reliability of the oilfield equipment. Therefore, there is a need to develop new technologies for wells with high ARP (Asphaltene-Resin-Paraffin) content.

Among the known methods for preventing the formation of ARPD and for removing existing deposits, the use of chemical reagents is the most efficient [5, 6]. The use of chemical reagents to remove ARPD is both economically advantageous and technologically promising for injection into the wellbore zone. These chemical reagents are also characterised by their long-term effects, even at low concentrations.

One of the superior parameters of chemical reagent efficiency against ARP is their high depressant properties. The more a chemical reagent lowers the freezing point of a paraffinic oil, the greater the efficiency achieved in the exploitation and transportation of these oils. Freezing point is one of the most important physical properties of oil. An increase in the freezing point leads to the formation of crystallisation centres and the growth of paraffin crystals. During the subsequent crystallisation process, a system is formed that thickens the liquid phase of the oil. The development of such a solid structure impedes the flow of the oil, resulting in increased viscosity and loss of fluidity [7].

Experimental section

Chemical reagents to combat ARPD are applied in appropriate doses and continuously (in the case of highly fluid product) or as a single application. Oil samples from Neft Dashlari and N. Narimanov Oil and Gas Production Department (OGPD) are classified as highly paraffinic oils due to their paraffin content exceeding 6.00% by mass. The individual properties of selected chemical reagents for solving paraffinic oil complications have been confirmed by laboratory research [9, 10]. Therefore, the effectiveness of a selected chemical reagent may not be universal for all oil fields. In other words, a reagent that gives positive results in one oil sample may not give the same results in samples from other fields. Therefore, new reagents called A-F1, A-F2, A-4F-1 have been developed in the laboratory. These reagents consist of a mixture of non-ionic surfactants and hydrocarbons of aliphatic and aromatic nature and their physico-chemical characteristics are given in table 1.

The kinematic and dynamic viscosities of the

Table 1

Physical-chemical indicators of paraffin deposition reagents

The brand name of the composition	The external appearance	Density 20 °C	Kinematic viscosity, 20 °C, mm^2/s	Freezing temperature °C	Solution	
					In water	In water
A-F1	Easy flow	0.872	3.24	-18	dissolve	Soluble
A-F2	Easy flow	0.886	5.35	-21	dissolve	Soluble
A-4F-1	Easy flow	0.924	7.25	-24	dissolve	Soluble

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reagents were determined using the Brookfield BL-PVSR-230 Rheotest and Anton Paar's SVM 3000 Stabinger Viscometer, while their densities were measured using the Anton Paar DMA 4500 M instrument.

Laboratory tests of the newly prepared A-F1, A-F2, A-4F-1 brand reagents were carried out on oil samples from «Neft Dashlari» and the N. Narimanov Oil and Gas Production Department (OGPD). The results of the tests are presented in tables 2 and 3.

As mentioned above, the comparison of these tables confirmed the validity of the ideas. As can be seen from tables 2 and 3, in the paraffinic oil sample obtained from the Neft Dashlari Oil and Gas Production Department (OGPD), the A-4F-1 reagent at a dosage of 200 g/ton at a temperature of 20 °C gave positive results, while in the paraffinic oil sample obtained from the N. Narimanov Oil and Gas Production Department (OGPD) under the same conditions it gave the opposite results. Laboratory researches have shown that the addition of A-4F-1 reagent in the dosage of 200 g/ton resulted in the dynamic viscosity of 367.50 mPa·s, kinematic viscosity of 393.09 mm^2/s, density of 0.9349 g/sm^3 and freezing temperature of -18 °C in the paraffinic oil sample obtained from «Neft Dashlari» Oil and Gas Production Department (OGPD). In the paraffinic oil sample obtained from the N. Narimanov Oil and Gas Production Department (OGPD), the addition of A-4F-1 reagent at a dosage of 200 g/ton resulted in a dynamic viscosity of 184.15 mPa·s, a kinematic viscosity of 197.06 mm^2/s, a density of 0.9345 g/sm^3, and a freezing temperature of -8 °C.

From table 2 it can be seen that the A-F2 reagent outperforms other reagents in terms of efficiency. Laboratory research has shown that in the paraffinic oil sample obtained from the N. Narimanov Oil and Gas Production Department (OGPD), the addition of A-F2 reagent at a dosage of 400 g/ton resulted in a dynamic viscosity of 121.43 mPa·s, a kinematic viscosity of 130.28 mm^2/s, a density of 0.9321 g/sm^3 and a freezing temperature of -10 °C at 20 °C temperature.

The effectiveness of A-4F-1 and A-F2 reagents against ARP (Asphaltene-Resin-Paraffin) was determined using the «cold finger» method, as it is closer to field conditions. This method allows both qualitative and quantitative evaluation of the efficacy against ARP. The experiments were carried out in the following sequence using a setup consisting of thermometers, glass flasks of 0.5-1 litre volume, a thermostat, magnetic stirrers, a lathe, a stirring element, a cruci-

Tables 2

Effects of reagents on paraffin deposition in the paraffinic oil sample obtained from «Neft Dashlari» Oil and Gas Production Department (OGPD)

Oil sample	The reagent of brand	Dose, g/t	Viscosity, 20 °C		Density 20 °C, g/sm^3	Freezing temperature, °C
			Dynamic mPa·s	Kinematic, mm^2/s		
control	-	-	3357.1	3590.76	0.9349	+16
I	A-4F-1	50	751.35	804.28	0.9342	-10
II		100	646.88	692.00	0.9348	-12
III		200	367.50	393.09	0.9349	-18
IV		400	493.64	528.36	0.9343	-15

Tables 3

Effects of reagents on paraffin deposition in the paraffinic oil sample obtained from N.Narimanov Oil and Gas Production Department (OGPD)

Oil sample	The reagent of brand	Dose, g/t	Viscosity, 20 °C		Density, 20 °C, g/sm^3	Freezing temperature, °C
			Dynamic mPa·s	Kinematic, mm^2/s		
oil	-	-	489.59	523.85	0.9346	+13
oil	A-F1	200	234.40	250.67	0.9351	-2
		400	132.75	142.42	0.9321	-7
oil	A-F2	200	190.00	203.06	0.9357	-7
		400	121.43	130.28	0.9321	-10
	A-4F-1	200	184.15	197.06	0.9345	-8
		400	167.07	178.75	0.9347	-9

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ble, resin hoses of the thermostat cooling system and the electrical network system:

First, the oil is heated to a temperature range of 45-55 °C. The oil is then poured into glass flasks at the same level. Cold fingers, circulated with water from the thermostat at the same level, are placed in the flasks and the shaft of the magnetic stirrer is placed on top. The thermostat and magnetic stirrer are then switched on. During the cooling cycle, the water circulating in the fingers circulates inside the flasks, cooling the oil until it approaches freezing temperature. At the end of the experiments, the efficiency is calculated according to the following principle:

$$Z_{İME} = (M_{ARPS} - M_{ARPS1}) \cdot 100 / M_{ARPS} : M_{ARPS} (Z_{İME})$$

Here: M_{ARPS} – the quantity of Asphaltene-Resin-Paraffin (ARP) precipitated with «cold fingers» in the absence of a paraffin deposition inhibitor; M_{ARPS1} – the quantity of Asphaltene-Resin-Paraffin (ARP) precipitated with «cold fingers» in the presence of a paraffin deposition inhibitor.

During the experiments, it was found that in the paraffinic oil sample obtained from N. Narimanov Oil and Gas Production Department (OGPD), the efficiency of A-F2 reagent at a dosage of 400 g/tonne was higher compared to other reagents. Conversely, in the paraffinic oil sample obtained from Neft Dashlari Oil and Gas Production Department (OGPD), the efficiency of A-4F-1 reagent at a dosage of 200 g/tonne was higher compared to other reagents.

The mechanism of action of the selected reagents is explained by their ability, at their respective concentrations, to influence the formation of crystalline structures during the initial process of paraffin crystal formation, thereby inhibiting their agglomeration. This is due to the presence of active substances in the reagent composition that delay the formation of dispersed phase structures induced by paraffin crystals. As a result, the freezing temperature decreases, the adhesion-cohesion forces weaken, and consequently the fluidity of the oil improves, facilitating its extraction with the oil stream.

The results obtained suggest that these reagents also have a positive effect on the rheological properties of the oil. Subsequent scientific research was therefore planned to study the rheological properties of these reagents, building on the successful laboratory experiments.

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