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FEATURES OF CHEMICAL TREATMENT TO PREVENT THE FORMATION AND REMOVE DEPOSITS IN PUMP-COMPRESSOR PIPES OF WELLS

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Well operation analyses show that the problem of asphalt-resinous and paraffin system deposition in pump-compressor pipes occurs mainly in low-flow, low-circulation wells with an oil temperature at the wellhead of 28–36^{0}C. The article analyzes some issues related to the technology for preventing the formation and cleaning of deposits in pump-compressor pipes, as well as the demulsification of stable oil emulsions by means of chemical action applied to the flow of extracted products. Using the example of Vietnamese fields, it is shown that cleaning with a biochemical composition of asphalt-resinous and paraffin deposits in pump-compressor pipes of wells is most applicable. Treatment of oil–water mixtures with dispersants increases fluid foaming and leads to increased gas-lift efficiency, as well as prevents the formation of stable oil emulsions.

Keywords: asphalt-resinous and paraffin deposits, gas-lift, dispersion, cleaning of deposits, pump-compressor pipes.

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Introduction

The problem of the deposition of asphalt-resinous and paraffin deposits (ASRD) in pump-compressor pipes (PCP) mainly occurs in low-flow, low-circulation wells operated using the gas-lift method, where the oil temperature at the wellhead is 28–36^{0}C. ASRD formation occurs when the well production temperature falls below the paraffin crystallization temperature. The results of deposit-prevention measures in pump-compressor pipes were analyzed using data from the VietsoPetro joint venture fields [1–6]. Figures 1 and 2 show data on deparaffinization operations in pump-compressor pipes for 2011–2024, indicating a general trend toward an increase in the number of well operations. The total downtime of wells and oil underproduction have remained approximately the same in recent years. In 2017, the large number of dewaxing operations was due to the commissioning of many wells and/or a decrease in the flow rates of OSP-5, OSP-10, CB-1, CB-14, CB-15, and CB-16 (Table 1).

Most newly commissioned facilities have low flow rates and initially begin operation using gas- lift, which further reduces the temperature of the product in the well and increases the formation of ASRD. From the above, it follows that the problem of ASRD formation in low-flow gas-lift wells with PCP is widespread, which requires the development of more effective methods to address it.

Analyses of works [7,8] showed that several technologies previously tested for removing and preventing the formation of ASRD in PCP did not show a significant effect. The following were tested: cleaning with a biochemical composition; flushing the PCP with organic solvents; a technology for increasing productivity and inhibiting ASRD by feeding a mixture of a depressant additive and a demulsifier (a non-ionic surfactant) into the gas-lift line;

parasqueezing technology – pressing the inhibitor and activator into the bottomhole zone with subsequent gradual removal. Thus, despite its low efficiency, the method of steaming the PCP and flushing with a gas–liquid mixture is the most widely used. Therefore, new technologies for inhibiting and removing ASRD from PCP must be sought [7,9].

Research methods, equipment, and instruments

The modeling process was carried out on a laboratory bench in accordance with ASTM D892, «Standard Test Method for Foaming Characteristics of Lubricating Oils».

The process of researching foaming and oil-foam stability was carried out as follows:

– study of foaming (maximum volume of oil foam) at a certain oil volume and gas flow rate with different dispersant dosages;

– study of foaming (maximum volume of water foam) at a certain water volume and gas flow rate with different dispersant dosages;

– study of foaming at different temperatures with different dispersant dosages;

– study of the stability of water–oil foam at different temperatures with different dispersant dosages.

Before testing, oil samples were degassed at high temperature. Non-ionic surfactants (dispersants) are ethoxylated fatty alcohols. Fatty alcohol ethoxylate is a colorless liquid. In the oil industry, they are used to remove liquids from the bottomhole zone of gas wells.

The following mixtures of chemical reagents were studied:

– RAO-32930 / UH-7484 depressant additives, which are used in pure form or in a mixture in a ratio of 7:3, with dosages similar to the current standard for the use of depressant additives.

– demulsifier RH-0190, which is supplied together with depressant additives at a dosage of 150 mL.

– dispersants (fatty alcohols), which are used in pure form or in a mixture at a dosage not exceeding 150 mg/L.

Results and discussion

It is known that gas-lift oil production in oil fields has been used since the second half of the 20th century. To date, the results have confirmed the correctness of choosing this mechanical method of production. Currently, most wells in oil fields are operated using the gas-lift method. At the fields, oil is extracted from different strata and horizons with different geological parameters and, consequently, different optimal gas-lift parameters. The flow rate of gas-lift wells varies greatly, from 5 to 300 tons per day. Wells with a flow rate of more than 60 tons per day are less complex than those with low production rates (less than 30–40 tons per day). The reason for this is that low-flow wells typically have lower wellhead temperatures than high-flow wells, and the intensity of ASRD formation in such wells is higher, which means that more heat is required to remove ASRD.

The results of the analyses show that the effective operation of gas-lift wells in oil fields largely depends on the parameters of the oil–gas–water mixture in the PCP and the ability of the gas-lift gas to disperse in the fluid flow [10].

It is easiest to explain how gas-lift gas helps improve the efficiency of a gas-lift well using the following formula:

$$\eta = \frac{1}{1 + \frac{\lambda_{cm} \cdot \upsilon_{cm}^2}{2gD}},$$

where η is the coefficient of efficiency; λ_{cm} and υ_{cm}^2 are the hydraulic resistance coefficient and the flow

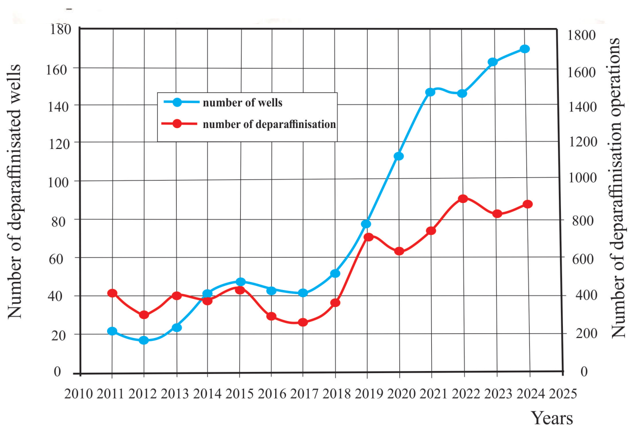

Fig. 1. Dynamics of well PCP deparaffinization operations in 2011–2024

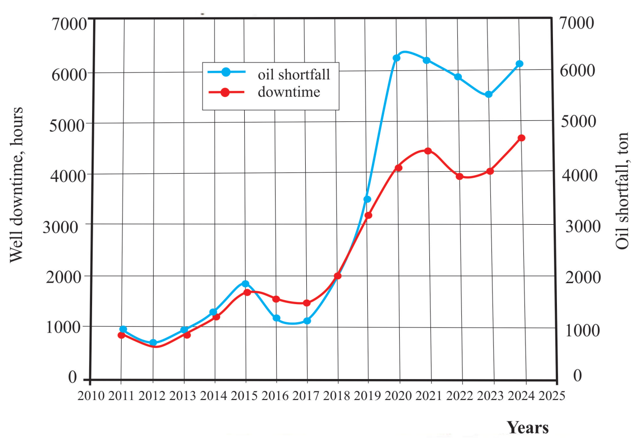

Fig. 2. Dynamics of idle wells and oil underproduction during deparaffinization of pump-compressor pipes for 2011–2024

rate of the gas–oil–water mixture, respectively; *D* is the lift diameter; and *g* is the acceleration due to gravity.

The problem of ASRD deposits in PCP mainly occurs in low-flow, low-water-cut wells operated using gas lift, where the oil temperature at the wellhead is lower than the paraffin crystallization temperature. As the ASRD layer on the PCP wall increases, eventually leading to complete blockage, the flow rate of oil and gas gradually decreases, resulting in

Table 1

Data on deparaffinization operations carried out in 2023

OSP (CB)*	Well	Number of operations performed in 2023	
		By well	Overall
OSP-1	27	1	1
OSP-3	193	3	3
OSP-4	40	1	1
OSP-5	102	30	182
	104	33	
	503	38	
	506	80	
	510	1	
OSP-6	90	37	37
OSP-10	1002	12	143
	1005	1	
	1007	14	
	1013	38	
	1014	12	
	1016	17	
	1019	11	
	1022	1	
	1023	37	
CB-2	418	1	2
	491	1	
CB-4	415Б	1	1
CB-14	1203	10	119
	1212	6	
	1214	13	
	1216	24	
	1217	13	
	1218	23	
	1219	12	
	1203Б	1	
	1220Б	6	
	17БТ	11	
CB-15	123	9	121
	125	49	
	132	30	
	20БТ	33	
CB-16	1604	31	220
	1606	60	
	1608	8	
	1610	58	
	1611	60	
	1612Б	3	

Note: * – OSP stands for «offshore stationary platform»; CB stands for «conductor block».

production losses. Such wells are periodically shut down to remove ASRD deposits from the inner wall of the PCP. The cleaning procedure is carried out weekly and takes 3 to 4 hours. The precipitated paraffin is removed by feeding steam directly into the PCP to melt the deposits. This method is simple and easy to implement, but it has several disadvantages, including the following:

– oil production shortfall due to well shutdown for deparaffinization;

– the effect is usually only apparent when removing ASRD deposited at the wellhead;

– high steam temperatures can cause problems for equipment flanges located at the wellhead, which can lead to malfunctions;

– diesel fuel and water consumption is required.

It should be noted that as the water content of well production increases, the efficiency of gas-lift systems decreases. There are several reasons for this. First, the physical properties of three-component mixtures differ from those of gas–oil mixtures. When dissolved gas is released intensively in the presence of water, an emulsion is formed, the viscosity of which may be higher than that of oil. The absolute value of the effective viscosity of the oil–gas–water system will depend on the percentage of each component in the mixture, their viscosities, the dispersion of the system, etc. Secondly, as the water cut of well production increases, the relative velocity of gas movement changes and the average density of the oil–gas–water mixture increases. All these processes in the wellbore of gas-lift wells occur under conditions of a decrease in the total amount of gas coming from the reservoir together with oil [11–14].

Therefore, increasing water content in well production is accompanied by a rise in total pressure losses, a decrease in gas efficiency, higher high-pressure gas consumption, and lower well flow rates. In this regard, one of the problems of operating water-flooded wells using the gas-lift method is to increase the efficiency of the energy supplied to the well with the working agent. This problem can be solved in the following ways:

– minimizing energy losses due to gas throttling in start-up and working valves. This is achieved by designing start-up valves that ensure well development with subsequent closure of the start-up openings and by selecting the optimal installation depth for start-up and working valves;

– minimizing energy losses in the flow by reducing the relative velocity of the gas phase and preventing the formation of highly viscous emulsions.

For this purpose, artificial dispersion of the gas phase, dissolution of part of the gas in the liquid at operating pressure, and modification of the properties of the liquid phase and the interphase boundary by using additives that affect the relative velocity of the gas phase, foam stability, emulsion viscosity, and the structure of the oil-gas-water flow can be used.

At the same time, the technology of chemical treatment of the extracted product should also be taken into account in order to increase the efficiency coefficient of the gas lift.

The chemical reagents proposed for use in treating the flow of extracted product can be divided into three groups:

– depressant additive – affects the structure of paraffin and leads to a decrease in pour point, viscosity, ASRD formation intensity, and surface tension;

– demulsifier – breaks down water-oil emulsions and reduces surface tension between phases in gas-liquid mixtures;

– dispersant – reduces surface tension between gas and liquid phases and creates foam structures.

In general, all chemical reagents have an organic composition, so they dissolve well in oil and in one another.

A demulsifier reduces surface tension at the oil–water interface and prevents the formation of a stable oil–water emulsion. However, under dynamic conditions, water dispersion in the PCP will still occur due to gas injection. The demulsifier prevents the formation of finely dispersed emulsions after the exposure is removed, i.e., after they leave the well, as well as after cooling and a decrease in velocity as a result of transport through pipelines.

To create gas–liquid structures, it is proposed to use fatty alcohols, which act as dispersants. Laboratory experiments have shown their effectiveness in creating foam structures. However, they do not form stable oil–water emulsions [7].

Previously, a technology was tested for injecting a complex chemical reagent (demulsifier+depressant) into a gas-lift line in order to increase gas lift efficiency and reduce ASRD formation. The essence of the method lies in the physical and chemical effect on the gas-liquid flow of a complex chemical reagent (CCR, a mixture of a demulsifier and an ASRD depressant-inhibitor). The ASRD depressant-inhibitor, which is part of this CCR, reduces the intensity of deposit formation in the PCP and improves the rheological properties of oil. The surfactant demulsifier temporarily stabilizes gas–liquid emulsions, improving the hydrodynamic properties of the gas–liquid flow.

The test results were ambiguous, partly because reliable control over the tests was not established – no PCP templates were used, and well flow rates were rarely measured. Unfortunately, no significant changes in the operating parameters of gas lift wells were observed, either in individual wells or in the MSP as a whole. Based on the results of laboratory studies, it has been shown that treating oil with non-ionic surfactants (dispersants) temporarily increases the foaming properties of oil. Non-ionic surfactants reduce surface tension and increase the solubility of gas in oil, thereby improving the efficiency of gas lift. It has been established that as water saturation increases, the lifting capacity of gas lift gas decreases. Therefore, it is necessary to search for new non-ionic surfactants capable of increasing the lifting capacity of gas lift gas at any water saturation level [15–18].

The results of the laboratory studies are shown in Table 2, and the results of the foam stability tests are shown in Table 3.

Chemical reagents used to treat the flow of produced fluids are organic in origin, which means they dissolve well in oil and in each other. Each chemical reagent can be used in its pure form. The reagents must be injected into the wells through a pulse line.

Conclusions

1. Process treatment of ASRD deposits in PCPs using biochemical compositions, despite its low efficiency, remains the most widely used method, which necessitates the search for new inhibition and removal technologies.

2. Treatment of water–oil mixtures with dispersants increases liquid foaming and enhances gas-lift efficiency, while also preventing the formation of gas pockets in the wellbore. Treatment of oil–water mixtures with dispersants likewise increases fluid foaming and improves gas-lift efficiency, as well as preventing the formation of stable oil emulsions.

3. RAO-32930/UX-7484 depressant additives should be used either in pure form or in measured dosages. The RH-0190 demulsifier should be injected instead of depressant additives at a dosage of 150 mg.

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Table 2

Results of foaming studies

Temperature, ^{0}C	Volume of oil sample, ml	Dispersant dose, ml	Volume of oil foam, ml	Efficiency, %
Oil sample from well OSP-5, water saturation 42%				
65	120	0	400	100
		25	620	155
		50	780	195
		75	890	222.5
		100	1020	255
		150	1500	375
35	120	0	350	100
		25	560	140
		50	710	177.5
		75	820	205
		100	960	240
		150	1100	275
Oil sample from well OSP-10, water saturation 14%				
65	120	0	4	100
		50	8	200
		100	14	350
		150	20	500
35	120	0	2	100
		50	6	150
		100	12	300
		150	16	400
Oil sample from well CB-15, water saturation 50%				
65	120	0	360	100
		25	610	152.5
		50	820	205
		75	1040	260
		100	1630	407.5
35	120	0	310	100
		25	580	145
		50	760	190
		75	970	242.5
		100	1400	350
Water sample taken from well CB-16				
65	1000	0	0	
		10	170	100
		20	560	140
		30	750	187.5
		40	900	225
		50	980	245
35	1000	0	0	
		10	170	100
		20	560	132.5
		30	750	180
		40	900	217.5
		50	980	232.5

Table 3

Results of foam stability tests

Temperature, ^{0}C	Volume of oil sample, ml	Dispersant dose, ml	Volume of oil foam, ml	Foam retention time, s
Oil sample from well OSP-10, water saturation 14%				
65	120	0	500	170
		25	500	190
		50	500	210
		100	500	200
35	120	0	450	180
		25	450	210
		50	450	220
		100	450	200
Water sample taken from well CB-16				
65	200	0	0	
		10	500	110
		20	500	120
		30	500	140
		40	500	160
35	200	0	0	
		10	500	100
		20	500	110
		30	500	120
		40	500	140

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ОСОБЛИВОСТІ ХІМІЧНОГО ОБРОБЛЕННЯ ДЛЯ ЗАПОБІГАННЯ УТВОРЕННЮ ТА ВИДАЛЕННЯ ВІДКЛАДЕНЬ У НАСОСНО-КОМПРЕСОРНИХ ТРУБАХ СВЕРДЛОВИН

С.Р. Расулов, М.Б. Адігезалова, Р.Й. Ганієва, М.М. Валієв

Аналіз експлуатації свердловин показує, що проблема утворення асфальтосмолисто-парафінових відкладень у насосно-компресорних трубах виникає переважно у свердловинах з низьким видобутком і низьким рівнем циркуляції за температури на гирлі 28–36^{0}С. У статті проаналізовано питання, пов'язані з технологією запобігання утворенню та очищення відкладень у насосно-компресорних трубах, а також демульсації стійких нафтових емульсій шляхом хімічного впливу на потік видобутих продуктів. На прикладі родовищ В'єтнаму показано, що очищення біохімічним складом асфальтосмолисто-парафінових відкладень у насосно-компресорних трубах є найбільш ефективним. Оброблення водонафтових сумішей диспергентами підвищує здатність рідини до спінювання та сприяє підвищенню ефективності газліфту, а також запобігає утворенню стійких нафтових емульсій.

Ключові слова: асфальтосмолисто-парафінові відкладення; газліфт; диспергування; очищення відкладень; насосно-компресорні труби.

FEATURES OF CHEMICAL TREATMENT TO PREVENT THE FORMATION AND REMOVE DEPOSITS IN PUMP-COMPRESSOR PIPES OF WELLS

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Keywords: asphalt-resinous and paraffin deposits, gas-lift, dispersion, cleaning of deposits, pump-compressor pipes.

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