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Efficiency of Application of Polyfunctional Reagents in Oil Gathering and Treatment Systems

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ABSTRACT: At present, it is important to use chemicals in oil field operations to inhibit the pipeline, field treatment of oil and utilization of formation water with simultaneous biocide treatment of equipment and formation.

KEYWORDS: corrosion inhibitors, QAS (quaternary ammonium salt), SRB (sulfate-reducing bacteria), demulsifier

I. INTRODUCTION

When transporting oil, the pipeline metal is exposed to corrosive media - highly mineralized formation water and hydrogen sulfide. For internal protection of pipes, special reagents are used - corrosion inhibitors, which due to their surface-active properties form a protective layer on the metal surface.

Then oil goes to primary treatment at oil treatment plants (OTP), where demulsifiers are used because of their surface-active properties, which ensure a high degree of oil dehydration.

Separated from oil, formation water is fed back into the reservoir for reservoir-pressure maintenance (RPM).Development of oil fields by flooding oil reservoirs leads to contamination with microorganisms, including the most corrosive sulfate reducing bacteria (SRB).Hydrogen sulfide, formed as a result of the life of SRB (sulfate reduction), causes corrosion of oilfield equipment, degrades the quality of oil and gas, reduces the reservoir permeability of formations up to complete isolation of individual oil-bearing horizons.

The water, which is separated from oil and then used in the reservoir-pressure maintenance system at the fields, contains active SRB cells of up to 109 cells/ml, which under favorable conditions can produce up to 400 mg/l of hydrogen sulfide, which causes local corrosion damage in the form of pitting, ulcers and grooves. If surface-active substances with biocide properties are introduced into water, the growth of anaerobic bacteria in the reservoir is suppressed, and the removal of the colonies can increase oil production from the reservoir by 5-8%.

The disadvantage of this scheme is that reagents of different classes and structures are used for each process. This, in turn, requires strict dosage, ensuring their absence in the next stage of the process, as well as in commercial oil entering the refinery[1-4].

II. LITERATURE SURVEY

In this aspect, the most effective and perfect is the use of polyfunctional compounds, which include quaternary ammonium salts (QAS). Due to their operational properties, they provide both inhibitor protection and demulsification, as well as bactericidal treatment of the well plume, OTP and manifold water supply system, which results in an increase in the integrated efficiency and profitability of inhibitor technologies, bactericidal treatment of field equipment and demulsification during the operation of the oil gathering and treatment system.

The task is achieved by using 90-95% aqueous or alcohol solutions of quaternary ammonium salts (QAS), alkydimethyl benzyl ammonium chloride of the general formula $[R(CH_3)_2(CH_2C_6H_5)N]^+Cl^-$, where R is a mixture of n-

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alkyl radicals $C_{10}H_{21}$-$C_{14}H_{29}$ (or individual radicals) with an average molecular weight of 310-368 g/mol. in the processes of oil transportation (as an inhibitor of all field equipment and demulsifier), demulsification at oil treatment plants (as a demulsifier, inhibitor and bactericide) and bactericidal treatment (as an inhibitor of all field equipment and bactericide).

The main physical and chemical characteristics of QASare presented in Table 1.

Table 1

Name of the indicator	**Value**
Density, g/cm^3	0,98
Viscosity, cSt	107
Flashing point, ^{o}C	over 100
Compatibility with water and alcohol	Unlimited solubility
Compatibility with petroleum products	Emulsion

Chemical reagents QAS, due to the presence of a quaternary nitrogen atom in the structure, as well as high molecular weight, have effective surface-active and biocide properties.A natural hydrogen sulfide-containing water-oil emulsion (WOE) from the «Kokdumulak» field in the Kashkadarya region of the Republic of Uzbekistan was chosen as a model with a 26% formation water content, up to 5.5 mg/l of hydrogen sulfide and over 24357 mg/l of salts.

The inhibiting capacity of the QAS depending on the concentration and aggressiveness of the environment determined by the gravimetric method in accordance with GOST 9.509-89 "Methods for determining the protective capacity" and GOST 9.905-82 "Methods of corrosion testing" is presented in Table 2.

Table 2

Reagent	Concentration, mg/l	Degree of protection against hydrogen sulfide corrosion, Z,%	After effect period, hour
QAS	10 25 50	95,0 99.0 99,5	10,5

As can be seen from Table 2, the proposed reagent has a high protective effect already at a content of 10 ml/g, and also has a aftereffect period of more than 10 hours. In addition, it is a water-soluble, fire and explosion safe,low-toxic (Class III) compound.

The biocide capacity of QAS determined by RD 39-3-973-83 "Methods for controlling microbiological contamination of oil-field waters and assessment of protective and bactericidal action of reagents" in relation to sulfate reducing bacteria (SRB) in the amount of 106 kl/ml is presented in Table 3.

As can be seen from Table 3, the proposed reagent is an active bactericide. In addition, it completely inhibits the growth of adhesive forms of SRB at dosages of 200-400 mg/l within 14-5 hours.

Table 3

Reagent	Concentration, mg/l	Suppression degree of the growth of planktonic form of SRB,%	Suppression degree of adhered forms of SRB,%
QAS	15 25 50 75 200 300 400	70,0 85,7 93,8 100,0	 82 95 100

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III. EXPERIMENTAL RESULTS

The results of the study of the demulsibility of the tested reagent are presented in table 4.

As can be seen from Table 4, the proposed reagent is a demulsifier by effectively breaking down the water-oil emulsion, separating water from oil without changing the time and temperature of the technological regime, and actively removing salts from oil.

Table 4

Reagent	Specific flow, mg/l	Temperature, °C		Time			Residual content	
		Stirring, min	Sludge	Stirring, min	Sludge, h	Extrac-ted	Water, %	Chlorine. salts, mg/l
Original WOE	-	-	55	-	2	8,0	25,0	24357,0
QAS	15 30 50	45 45 45	55 55 55	5 5 5	2 2 2	22 24 24	0,15 0,05 0,00	442,2 227,4 174,4

Analysis of the data in tables 2-4 shows that the proposed reagent is an effective biocide and hydrogen sulfide corrosion inhibitor, at the same time it has - high demulsibility

Patented [5] "Method of operation of the oil gathering and treatment system" for operating the oil transportation system, oil treatment and flooding according to the following scheme (figure):

- During oil transportation, the metal of the oil pipelines (position 1) is exposed to corrosive media - highly mineralized formation water and hydrogen sulfide. For internal protection of pipes, a polyfunctional chemical reagent, QAS, is used as a corrosion inhibitor (position2), which, due to its surface-active properties, forms a protective layer on the metal surface and at the same time results in the process of in-line demulsification and bactericidal treatment of all field equipment;

- then oil is delivered to the primary treatment at oil treatment plants (OTP) (position 4), where the QAS is used as demulsifiers (position 5), due to its surface-active properties, providing a high degree of oil dehydration, and at the same time inhibitory protection of reservoirs and associated OTP equipment. Separators at the inlet and outlet of OTP (position 3) separate free formation water and its residues respectively;

- the bound formation water separated from oil at the OTP is fed back into the reservoir for reservoir-pressure maintenance (RPM) (position 7).Development of oil fields by flooding oil reservoirs leads to contamination with microorganisms, including the most corrosive sulfate reducing bacteria (SRB). Water recharge from open reservoirs (position 8) also contains active biocoenosis, which has a negative effect on corrosion in water pipelines and other field equipment.Hydrogen sulfide, formed as a result of the life of SRB (sulfate reduction), causes corrosion of oilfield equipment, degrades the quality of oil and gas,and reduces the reservoir permeability of formations up to complete isolation of individual oil-bearing horizons. The introduction of QAS as a corrosion inhibitor and bactericide (position 9) into the installation for RPM protects the equipment from hydrogen sulfide and biocorrosion (position 10).

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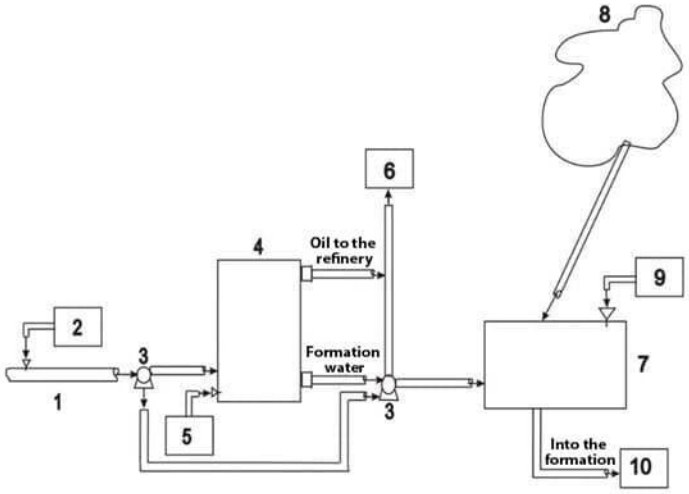

1-oilpipeline; 2-container with QAS; 3-separators; 4,5 - OTP; 7 – RPM; 8-recharge reservoir; 9 – QASsupply; 10 – introduction into the RPM

Operation scheme of oil gathering and treatment system with the use ofQAS

IV. CONCLUSION AND FUTURE WORK

The technological advantages of applying the QAS are [5]:

- the processes of oil transportation, demulsification and flooding are accompanied by simultaneous inhibition and bactericidal treatment along the entire process line, which makes it possible to increase the accident-free operation time of the line by 23-25% as a result of metal protection and suppression of sulfate reducing and other bacteria growth;
- the presence of the demulsifying properties of the QAS causes the use of oil trap tanks and settling ponds to be refused, as demulsification flows along the entire process line, reducing the losses of oil with water by 35-40%;
- the number of settling tanks is reduced by 30%;
- as a result of reduced demulsification time, the loss of light oil fractions is reduced by 25-28%;
- there is no need to select inhibitors, demulsifiers and biocides in a compatible manner;
- the possibility of oil contamination with demulsifier or inhibitor owing to the unlimited solubility of QAS in formation waters is excluded;
- the time required for demulsification is reduced, as this process begins already in the pipeline when oil is transported by introducing the QAS as an inhibitor;
- the process of suppressing biocoenosis growth is accelerated, as there is an QAS to some extent in the formation water entering the RPM;
- the economic efficiency of the QAS is due to the preservation of the metal fund from aggressive media, low chemical consumption at any stage of oil treatment, and the possibility of wholesale purchase and storage in warehouses, which will ensure the continuity of the oil treatment process..

In order to optimize the introduction of the QAS into the oilfield transportation and treatment system, a Policy Document [6] «Calculation of the dosage of polyfunctional reagents based on quaternary ammonium salts in the oilfield transportation and treatment system»was developed. Tables 5 and 6 present calculations of the dosage of polyfunctional reagents based on quaternary ammonium salts in the oilfield transportation and treatment system (programming language - Delphi XE3, operating environment - Windows 7, volume - 2664960 bytes).

Thus, for the first time, the need has been established for the selection of chemicals for oil transportation and field treatment systems that have complex properties - at the same time as an inhibitor, demulsifier and bactericide, for example, on the QAS base.

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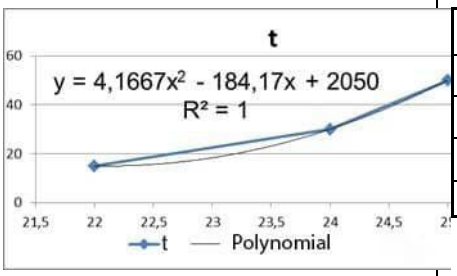
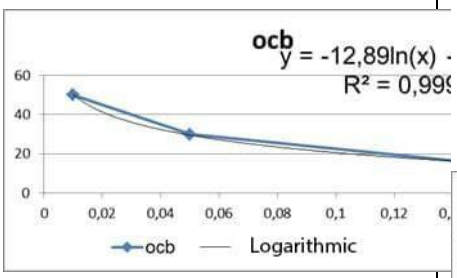
Table 5

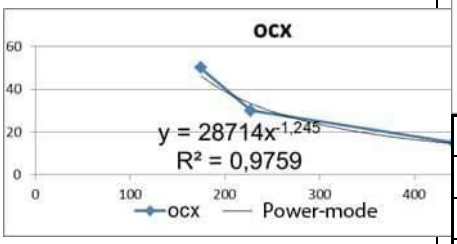
Reagent demulsification capacity

β	t	ocb	ocx
15	22	0,15	442,2
30	24	0,05	227,4
50	25	0,01	174,4

Calculation using the demulsification formula			
15,389	22,0	0,15	442,2
19,676	22,5	0,12	300,0
23,441	23,0	0,10	250,0
27,286	23,5	0,08	227,4
32,023	24,0	0,06	210,0
39,680	24,5	0,03	190,0
49,709	25,0	0,01	174,4

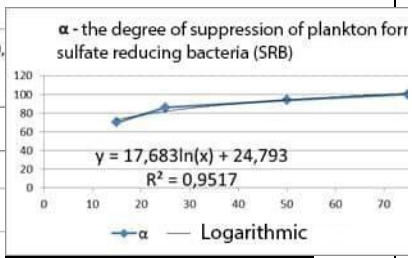






Reagent biocide capacity

α	K, mg/l
70	15
85,7	25
93,8	50
100	75



β	K, mg/l
82	200
95	300
100	400

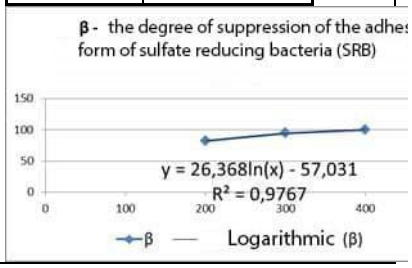


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Table 6

Reagent demulsification capacity

β	t	ocb	ocx
15	22	0,15	442,2
30	24	0,05	227,4
50	25	0,01	174,4

Calculation using the demulsification formula			
15,389	22,0	0,15	442,2
19,676	22,5	0,12	300,0
23,441	23,0	0,10	250,0
27,286	23,5	0,08	227,4
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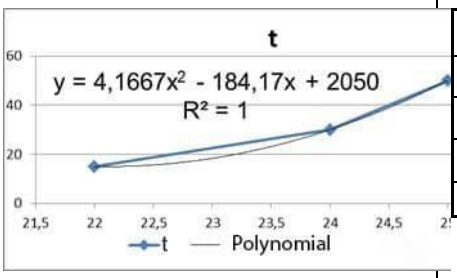
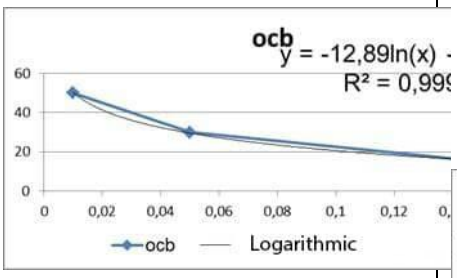
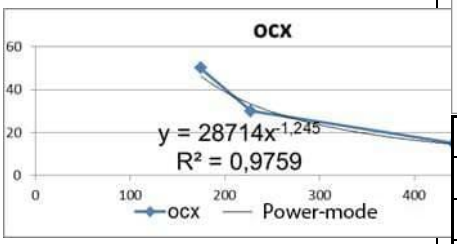
39,680	24,5	0,03	190,0
49,709	25,0	0,01	174,4

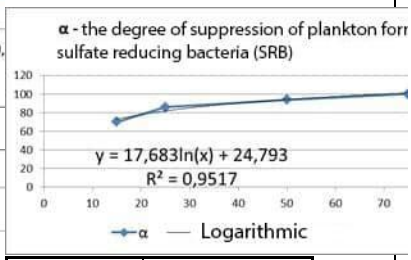






Reagent biocide capacity

α	K, mg/l
70	15
85,7	25
93,8	50
100	75



β	K, mg/l
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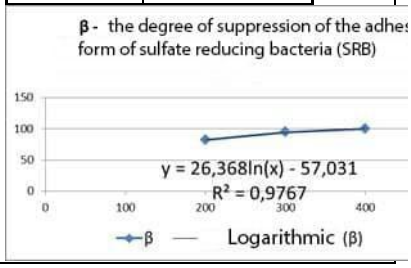
95	300
100	400



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