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Scaling Prevention on Wells of Tarasovskoe Field

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***Abstract* — Tarasovskoe oil and gas condensate field is located in the Purovskii district of the Yamal-Nenets Autonomous District of the Tyumen Region, 55 km north of Tarko-Sale town and 45 km east of Gubkinskii town. One of the main drawbacks of the existing field development system is a large stock of non-operating wells. The utilization rate of the production well stock at the field is 0.71, the rate of the injection well stock - 0.64, which leads to an oil production decline, and, resulted in deformation of the developed system, prolonged underutilization leads to significant losses in the ORI value. The main task is the struggle with scaling. At the Tarasovskoe field, the most urgent task is to reduce the risks of scaling, optimize the technologies used, and select priorities in the use of the latest technologies for the prevention of scaling. The main source of salt extraction is water extracted together with oil. The scaling process is directly connected with a significant oversaturation of the aqueous medium with difficultly soluble salts due to changes in the physicochemical parameters of the oil production system (temperature, pressure, gas evolution, concentration of precipitating ions, etc.). The chemical composition of production waters as oil reserves are constantly changing, which causes the diversity and time variability of the salt deposits composition. Forced fluid withdrawal, which is associated with the deepening and temperature increase in the ESP zone, lowering the bottomhole pressure and intensive degassing of well fluids, affects the intensity of salt deposition at different sites from bottom to bottom of the well, at submersible borehole pumps. In addition, the deposition of salts in the bottomhole formation zone leads to an increase in the skin factor, and therefore becomes a reason for the decrease in oil production in production wells. In this regard, the choice of optimal options for the prevention of scaling, taking into account the features of the operation of wells in specific fields, is extremely important for effective oil production.**

Key words — Tarasovskoe field; hydrocarbon saturation; scaling; inhibitor; watering; well; rock.

I. INTRODUCTION

The key task of the development of the Tarasovskoe field is the maximum possible oil and gas production with a low level of technological and economic costs per unit of production. To solve the key task, it is necessary both to involve new reserves in the development (bringing wells out of inaction, drilling new wells), and improving the efficiency and optimization of the main elements of the existing stock [1-3].

The stability of the optimization process is based on an analysis of existing technological processes and rational prioritization in order to create processes of directional impact.

The segment of the production process that consumes the most resources is a block of mechanized lift. More than 80% of the total economic costs at the Tarasovskoe field depend on the quality of controlling the lift processes in a mechanized way.

The main indicator characterizing the efficiency of the mechanized stock is mean active repair time (MART) – the average duration of operation upon the well, as well as the average time between failures (ATBF) - work period between two consecutive failures. These figures affect the complex cost of the production cycle, the key elements of which are the cost of acquiring or repairing underground equipment, indirect losses during downtime, and underground repair of wells.

The costs for the mechanized stock are affected by: removal of solid suspended particles from the reservoir (blockage, pump destruction) – 54% of failures; the deposition of salts on the surface of the working bodies of ESP - 18%; small inflows (equipment operation outside the working range due to a decrease in inflow caused by mudding salts in the bottomhole formation zone) – 9% [4, 5].

The struggle with scaling on the working bodies of equipment is one of the most effective modern technologies, as a way to solve an actual production problem.

Reservoirs at the Tarasovskoe field are mainly represented by terrigenous deposits of Neocomian age. The deposit is multi-field and multilayer.

The field is in the third stage of development and is characterized by declining oil production.

A combined RPM system is used. A closed block-square well placement system with a grid density of 600 × 600 m was created for the BP8 and BP9 facilities, along the BP10-11 formations (without subgas zone) and BP14 - areal 9-point waterflood system with well placement on a 600 × 600 square grid m. The density of the bottomholes – 36 ha/bth.

The dynamics of the irrigation of the Tarasovskoe field reservoir are influenced by several factors: geological heterogeneity of the well section, zonal heterogeneity of the reservoir, location of the wells (PNN or VNZ, marginal or central zone of the reservoir), the distance between the producing and injection wells. The dynamics of watering wells for different layers is almost identical and is characterized by a rather long dry period and then a rapid jump to a water content of 85 - 95%.

In the general structure of the existing oil well stock of the Tarasovskoe field, 54% are equipped with electric centrifugal pumps (ESP), which provide more than 88.3% of the total oil production [5].

Analysis of the problems of the most relevant areas is carried out systematically at the field. The mechanized pool of oil wells is grouped by complication (degree of scaling, removal of mechanical impurities, the effect of high temperature, the effect of gas, etc.).

The dynamics of the ATBF indicator of the mechanized well stock has a tendency to decrease due to the systematic work of geological and technical measures (GTM) - hydraulic fracturing and intensification of production. Moreover, the beginning of salt deposits was detected on all these wells.

To prevent complications associated with salt deposition, various technologies are used to reduce complications and, consequently, to maintain and increase ATBF and MART [5, 6].

The main reasons for the formation of salts in oil wells in the development of fields developed by OJSC RN-Purneftegaz include:

- a decrease in pressure and an increase in the temperature of the produced fluids, which leads to the release of dissolved carbon dioxide into the gas phase and precipitation of calcium carbonate;
- a decrease in the CO2 content in the solution leads to a decrease in the concentration of carbonic acid, which increases the pH of the solution, and, as a consequence, significantly reduces the solubility of CaCO3;
- mixing incompatible waters (usually extracted water contains calcium, barium and strontium cations and mixing them with injected water containing sulfate ions, leads to the formation of insoluble sulfates, such as barite, celestin, gypsum and anhydrite);
- evaporation of aqueous solutions upon contact with heated equipment (ESP electric motors) leads to a supersaturation of fluids limited to soluble salts and their salting out. This mechanism is implemented in low-watered wells operated by ESP and, especially, in wells with high pressure and temperature (the so-called "HP/HT").

Currently used methods of intensive impact on the reservoir simultaneously with the use of modern high-performance electric submersible pumps (ESP) are necessary, first of all, to maintain the design rate of field development [6].

The most serious danger is represented by scaling on the working parts and surfaces of ESP. An inhibitor is used to prevent this. To deliver the inhibitor to the well, the method of constant dosing into the annulus of the well is applied by an individual metering unit of the wellhead reagent supply (WRSU).

At present, mainly organophosphorus inhibitors are used to prevent scaling in oil production, both in solid and in liquid commercial form. They are distinguished by their relative cheapness and low effective dosage. They are thermally more stable in contrast to inorganic polyphosphates, which hydrolyze and transfer to orthophosphates, which form insoluble precipitates with calcium ions [3].

The oil industry has established requirements for the technological characteristics of scale inhibitors.

The final choice of reagent according to the technological characteristics is recommended to be done according to the scheme of selection of the inhibitor of salt deposits for the protection of oil field equipment in the process of oil extraction and preparation, developed by All-Russian Scientific Research Institute for the collection, preparation and transportation of oil ("VNIISPTneft") [7].

This method is based on determining the time of appearance of the solid phase of a precipitating salt (CaCO3, CaSO4 or BaSO4) in its supersaturated solution. The time of appearance of the solid phase in the supersaturated solution is called the induction period. In the method under consideration, the latter is found from the time variation of the transmittance of the supersaturated solution determined by the optical method.

The compatibility of the reagent with the formation water of a given field is determined by mixing it with inhibitor solutions of various concentrations. If the inhibitor is incompatible with formation water, the solution becomes cloudy or a viscous gel appears in it.

By reducing the weight of control samples immersed in the working solutions of inhibitors, determine the corrosivity of salt deposit inhibitors [7].

The effect of inhibitors of salt deposits on the quality of oil preparation is determined by the change in the content of salts and water in the oil of this field, as a result of which the oil is treated with a mixture of inhibitor and demulsifier [5].

The effectiveness of the reagents was determined by the inhibition of calcium carbonate deposition on the reservoir water models with a solution stability of 0.9, 1.7 in accordance with RD 39-0148070-026VNII-86 "Technology for the optimal use of scale inhibitors".

II. METHODS AND MATERIALS

An integrated approach implemented within a single software module allows predicting scaling based on the distribution of characteristics (temperature, pressure, gas content) of a multiphase flow in a well, obtained by calculating the pump operation mode, and automatically downloading data on the chemical composition of formation water and gas , quantify the risk of scaling in different parts of the well using the saturation index, make recommendations on the choice of a warning technology laying down with determining the type and dosage of the inhibitor, predicting an increase in time between failures and calculating the economic effect of measures to prevent scaling [9].

Method J. E. Oddo and M.V. Thomson allows you to determine the degree of saturation of the solution with calcium carbonate in the wellbore of the production well, allowing the modeling of the salt deposition profile in the corresponding well. In this method, cases of possible precipitation of calcium carbonate from a solution, as the most common type of carbonate scaling, are considered during the movement of an oil-water flow with the gas phase and in its absence.

III. RESULTS AND DISCUSSIONS

Taking into account the ionic composition of produced water at a particular well, the change in thermodynamic conditions and CO2 partial pressure during the movement of well fluids in the well, heating of the produced fluids by a running submersible electric motor (SEM) of a centrifugal pump pumping installations of the Tarasovskoe field [10].

Figures 1-3 show the simulation results of calcite deposition along the wellbore with reduced descent depths of pump installations of the Tarasovskoe field.

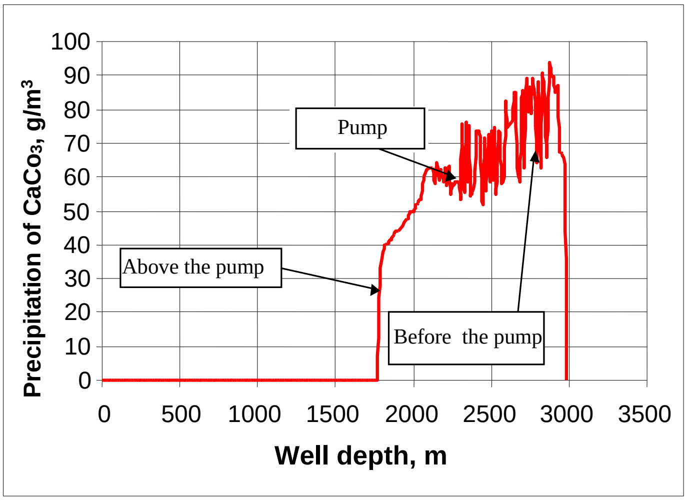

Fig. 1. Intensity of calcite deposition (well № 411).

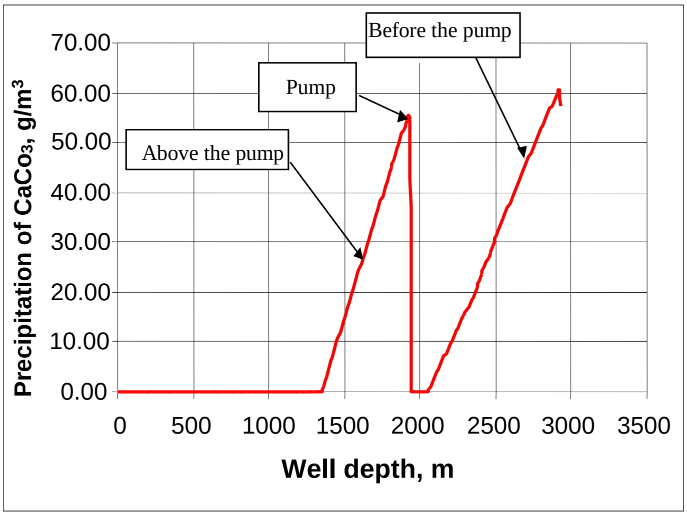

Fig. 2. Intensity of calcite deposition (well № 422).

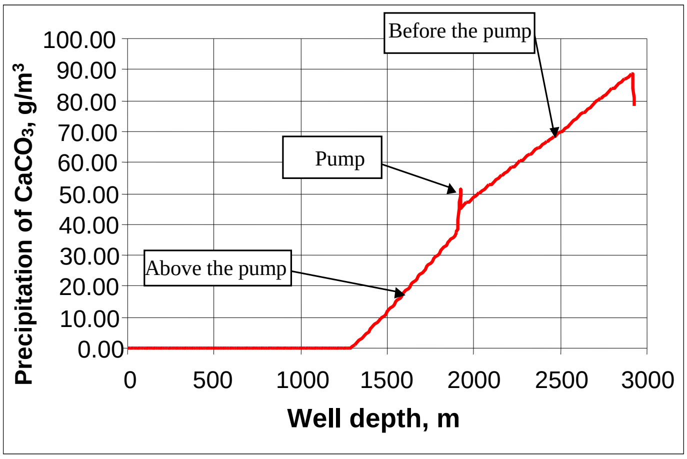

Fig. 3. Intensity of calcite deposition (well № 645).

TABLE I. EFFICIENCY OF SALT EMERGENCY INHIBITORS APPLICABLE TO WATERS OF VARIOUS ION COMPOSITION

Water stability index	Component composition	Concentration, g/l	Inhibitor	Protection (in %) at dosage, mg/l			
				10	20	50	10
1.7	$CaCO_3$	0.55	INSAN	–	78	93	100
		1.655	SNPKH-5311	–	37	54	70
		0.42	Sinol-IS-001	–	78	86	93
		22.6	Marka T	–	–	95	100
0.9	$CaCO_3$	3.33	KHPS-005	–	75	88	75
		0.275	INSAN	–	96	98	100
		0.42	SNPKH-5311	–	70	80	90
		21.195	KHPS-005	–	–	35	50

Table 1 presents the results of experiments on the testing of reagents on the effectiveness of preventing the precipitation of calcium carbonate in solutions [11].

The conclusion about the inhibiting and other technological properties of the reagent intended for the protection of technological equipment for oil preparation from salt deposits is made on the basis of the performance of all types of tests and the compliance of the obtained results with the requirements of the suitability of reagents for the protection of technological equipment for oil preparation.

According to the test results, a protocol and test report are compiled in the established form with a conclusion on the expediency (or inexpediency) of conducting pilot tests of this reagent.

Formation waters of the Tarasovskoe field belong to the potassium chloride type. For this type of water (stability indicator 0.9), injecting a scale inhibitor INSAN, dosages of 20-50 mg / l are recommended.

This scale inhibitor, slightly inferior in efficiency to the SNPCH-5311 reagent, is less corrosive with respect to metal equipment in contact with it. Therefore, for injection into the annulus is proposed to use the inhibitor INSAN.

THE SCALE INHIBITOR INSAN IS A WATER-ALCOHOL SOLUTION OF ORGANIC PHOSPHATES AND PHOSPHONATES.

In terms of physico-chemical parameters, the scale inhibitor of INSAN must meet the requirements and standards: the appearance is a homogeneous liquid having a light yellow color, its density at 20 °C ranges from 1055 to 1075 kg / m3, the concentration of hydrogen ions (pH) in redistribution from 1.5 to 2.5, the crystallization temperature is minus 45 °C, the effectiveness of inhibiting the precipitation of calcium carbonate is not less than 85% at a dosage of 20 g / mt.

According to the russian state standard (GOST) 12.1.007, the scale inhibitor, according to the degree of impact on the body, belongs to low-toxic substances, it is difficult to flammable, fire-and explosion-proof [12].

The accumulated experience of operating the ESP system shows that when they are buried, the conditions of the heat transfer of the SEM deteriorate and intensive extraction of the produced fluids occurs.

As a result, the solubility of calcite, the main component of scaling in the wells of the West Siberian region, decreases. The degassing also contributes to the precipitation of calcite due to the decrease in the content of dissolved carbon dioxide in the aquatic environment.

With the intensification of scaling in the receiving zone of the ESP from the positive side, the technology of constant dosing of the scaling inhibitor into the annulus of the well by ground dosing units OWBP has recommended itself.

Analysis of the operation of complicated wells equipped with showed that the coefficient of increase in time between failures of ESPs on average increased by more than 2 times [13].

The large-scale application of the technology of constant dosing of a scale inhibitor using WRSU will reduce the number of salt failures.

The effectiveness of the wellhead reagent supply unit injection of scale inhibitor INSAN in wells number 411; 422; 493; 645 Tarasovskoe field is shown in Table 2.

TABLE II. EFFICIENCY OF APPLICATION OF INSTALLATION OF THE WELLHEAD REAGENT SUPPLY UNIT ON WELLS OF THE TARASOVSKOE FIELD.

Indicator	**Well Number**				**Total**
	411	**422**	**493**	**645**	
q_1, mt/d	7.348	6.057	13.811	9.901	–
q_2, mt/d	7.348	6.057	13.811	9.901	–
T_1, d	170	164	171	174	–
T_2, d	286	277	285	292	–
$Q_{н1}$, m/t	1249.16	993.348	2361.51	1722.6	6326.618
$Q_{н2}$, m/t	2101.528	1677.789	3935.85	2890.8	10605.97
$Q_{доп}$, m/t	852.368	684.441	1574.34	1168.2	4279.349

As a result of the use of the WRSU, the turnaround time of the well operation increased on average by 1.68 times, as a result of which additional oil production was obtained in the amount of 4,279,349 tons

The proposed technological solution is the introduction of the reagent wellhead at the well No. 437.

IV. CONCLUSION

As a result of the design, the following tasks were performed: technological solutions were proposed to prevent salt deposits, the economic feasibility of the project was calculated, a system of measures was proposed, the purpose of which is to ensure environmental and industrial safety.

The key technological solution is the installation of WRSU. The installation helps to increase the turnaround time of the pumps, reduce the technological and economic costs of repairing them due to the reduction in the number of repairs and obtaining additional production of borehole products by increasing the operating time of the pumps. The project payback period is 0.3 years.

It was found that the economic activities for the installation, operation of WRSU, which is planned during the implementation of the project, will have a negligible impact on the environment.

Technological solutions that are provided in this article, as established during the analysis, are technologically effective, are carried out in accordance with the current requirements for labor protection, industrial safety, and will not cause significant harm to the state of the environment.

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