International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 24 (2015) pp 45360-45365
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Methods of fighting against scale build-up at the Tuymazy deposit

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Abstract: During the oil production continuous scale build-up takes place by using any operation modes. Increases the pump wear on the working faces, presence of non-organic salts and results in seize of the shaft of electrical centrifugal pump (ECP) and plunger of the subsurface pump, impeller damage. Under these conditions of operation of the mechanized well stock the turnaround is reduced significantly. This is why fighting against scale build-up and prevention of formation thereof is essential. In practice, the main task is identification of the composition and location of salt deposits – the first step is removal thereof and design of efficient methods. Inhibitor removal time in some measure depends on the rate of absorption of salt deposits inhibitor on the productive stratum surface. At the same time the slower its desorption from the formation is and the higher the adsorption of the inhibiting matter is the more efficient and long-lasting is scaling prevention. Scaling prevention is achieved with the use of inhibitors at optimum dosages the values of which in formation water are determined by content of salt-forming ions Ca^{2+} and HCO_3^-. On the basis of results of experimental works performed on analysis of efficiency of scaling for waters of different ion composition an inhibitor is selected and its optimum dosage is determined.

Key words: oil production, scale build-up, inhibitors, force fields

1. INTRODUCTION

Oil production is a complex process during which a variety of factors shall be taken into account: from geologic structure of deposits and specific impact of the advanced recovery methods (ARM), in particular tertiary ones, on the composition and properties of fluids produced, to the mineral composition of formation waters, their compatibility with water used for formation-pressure maintenance [1, 2]. During oil and gas production salts are deposited on the equipment of a wide range of deposits and internal surface of field pipelines. Salt gel bearing against the internal surface is accumulated in production strings, surface facilities and oil-well tubing forming a layer of a few centimeters thick. Increased scale build-up results in reduction of the production rate due to increase in the piping surface roughness and the flow passage is reduced. Therefore, production is declined and the pressure is built-up. It becomes impossible to reach the subjacent well sections as crystals grow at the

same time the pipe flow is reduced significantly.

The first cause of scale build-up is mixing of chemically incompatible waters of different composition, the second one – variation of pressure, temperature, gas liberation. All of this results in that the actual concentration exceeds the equilibrium one and the substance fall-out from the solution takes place.

As of today this issue is topical for the oil industry as most of mature deposits with complicated production conditions are characterized by high watering of products which in its turn is a favorable condition for formation of different deposits [7, 8].

There are reagentless and chemical methods of scaling prevention. Chemical ones are: use of highly-mineralized water, use of different kinds of inhibitors. Reagentless: structural alteration of equipment, protective coating of the piping surface as well as exposure of the solution to magnetic force fields.

The efficiency of measures aimed at fighting against scale build-up by oil production depends on the integrated approach to solution of this issue. It is necessary to know the physico-chemical processes and causes related to scale build-up under different conditions of oil occurrence, to be able to forecast in advance, timely prevent and be firmly in control of possible appearance of salt deposits during the well operation. Special attention shall be paid to selection of the necessary methods of fighting against scaling which will allow providing the maximum efficiency with account for the economic viability in the specific field conditions [4].

Let's consider the Tuymazy deposit. At this deposit chemical methods are actively used since use of chemical reagents-inhibitors is the most efficient one from among the existing methods of scale build-up prevention. For inhibition of carbonate and sulfate scale inhibitors СНПХ-5301, СНПХ-5312С are recommended, ferrous scale – СНПХ-5313 designed by NIINEFTEPROMKHIM (Kazan), most frequently used for relatively high-permeability formations. For fighting against sulfate and sulfide-containing scale inhibitor ПАП-С-1 designed by the 'IPZ Intech' LLC can be used, the new reagents of the СОНСОЛ-2001 and СОНСОЛ-2002 series (carbonates and calcium, ferrous and barium sulfates) designed by the CJSC 'Pilot plant NEFTEKHIM' as well as removers-inhibitors СОНСОЛ-3003м, СОНСОЛ-3001 designed for removal and prevention of carbonate and sulfide-containing scale [4].

The area of application of scale inhibitors regardless of the operation mode – all permanently operated wells. Prevention of deposition of non-organic salts on pumping equipment and production well is achieved by means of treatment of the produced water with scale inhibitors using different techniques. There is the optimum value of content of

inhibitors ensuring scaling prevention for water produced from each well complicated with scale.

1. PRELOADING THE SCALE INHIBITOR SOLUTION IN THE BOTTOMHOLE FORMATION ZONE

The technology used in all wells operated either periodically or permanently regardless of the operation mode for the entire range of capacities within which inhibitor solution can be set in the bottom hole formation [5].

It is not recommended to perform well treatment using this technology upon the low reservoir properties.

Table 1. Scale inhibitors recommended for deposits of the Tuymazy oil production department

Kinds of non-organic salts	Scale inhibitor	Dosage, mg/l	Notes
Gypsum	СНПХ-5312С	15-20	
	ПАП-С-1	15-20	
	СОНСОЛ-2002а	15-25	Modified according to the conditions of the Tuymazy oil production department
Carbonates	СНПХ-5312С	25-30	
	ПАП-С-1	15-20	
	СОНСОЛ-2002а	20-25	Modified according to the conditions of the Tuymazy oil production department
Barium salts	СОНСОЛ-2001Б	20-35	Modified according to the conditions of the Tuymazy oil production department
	ХПС-007	30-40	
Sulfide-containing	СНПХ-5313	50-70	
	ПАП-С-1	30-45	

2. CONSTANT DOSING WITH THE USE OF MEASURING DEVICES

The area of application – all wells equipped with ESP unit (electrical submersible centrifugal pump unit) or EDP (electrical diaphragm pump unit) and wells equipped with sucker-rod pumping unit with the capacity over 5 t/day.

It is recommended to perform constant dosing of scale inhibitor with the use of measuring devices through a capillary cable or armored capillary. In order to provide constant inhibitor dosing a vessel, на устье скважины устанавливается емкость, dosing apparatus are mounted on the well mouth and connected through the known circuits to the annular space.

Let’s calculate inhibitor demand for the technology of constant inhibition of well troubles. The volume ratio of water in the

well-produced products (n_0) is calculated according to the formula

$$n_0 = \frac{0,15}{\left[0,15 + (1-0,15) \times \frac{1005}{867,5}\right]} = 0,132$$

The inhibitor amount dosed into a well (P, kg/day) is calculated according to the formula

$$P = P_0 \times Q_{ж} \times n_0 \times \gamma_з / 10^6$$

- During the first 10 days of the 'shock dosage' mode -

P_n=5×30=150г/т;

P=150×0,132×1005/10^6=0,399 kg/day

- Upon expiry of the 10-days term in the 'optimum dosage' mode -

$P_0 = 30$ г/т ;

P=30×20×0,132×1005/10^6=0,080 kg/day

3. PERIODIC FILLING

Regardless of the operation mode the technology is used within the entire range of capacities and in all wells that are operated constantly.

Periodic filling of scale inhibitor in the annular space of the flowing well may be performed either with the use of pumping method or the device (dropper) [6].

Let's calculate the inhibitor demand for the technology of periodic inhibition of well troubles

Water recovery from the bottom whole is estimated

The Reynolds number for oil is calculated according to the formula

$$R_e = 1,274 \times (1-0,132) \times \frac{1,231}{172800 \times 0,062 \times 2,16 \times 10^{-6}} = 1176$$

Since $2600 \times 0,062^2/(0,062^2 + 0,062^2)$ =2080>1800 then water from the bottom hole is not completely recovered and period inhibition technology may be used for scaling prevention.

Density of gas-saturated fluid $(\gamma, \frac{кг}{м^3})$ is calculated according to the formula

$$\gamma = \frac{\left[867,5 + 1,096 * 70,3 + 1005 \times \frac{0,132}{1-0,132}\right]}{\left[1,231 + \frac{0,132}{1-0,132}\right]} = 793,48$$

The fluid volume in the bottom hole and within the annular space $(V_з, м^3)$ is calculated according to the formula

$$V_з = 3,14 \times 0,073^2 \times (2600 - 1800) + 3,14 \times ($$
$$= 18,12$$

The inhibitor amount supplied (P, kg) supplied to the bottom hole is calculated according to the formula

P=2,0×30×793×0,15×

(20×30+18,18)/$10^6 = 4,4\ kg$,

Where K=2,0 – rate of increase in the inhibitor consumption taking into account irregularity of inhibitor recovery from the well bottom hole;

τ –Treatment frequency – every 30 days.

Since P=4,4 kg then during the by initial treatment it is recommended to fill in 50 kg of the inhibitor.

If non-organic salts have been already deposited it is recommended to remove them.

Prior to well treatment for removal of non-organic salts deposits in the subsurface equipment and production string they shall be previously cleared out of (ARPD) asphalt, resin and paraffin deposits, such cleansing may be performed by means of treating the downhole pumping equipment with the ARPD solvent in the amount 1,5-5,0 tons.

By using the scale inhibitor СОНСОЛ-3003м no preliminary treatment with the ARPD solvent is required.

Removal of calcium sulfate salts (gypsum) is performed by means of treatment of the scale bridge with the solution of 20-25 volume ratios of caustic soda with further removal of reaction products with 15 volume ratios of hydrochloric acid or mechanically [5].

The solvent-inhibitor consumption is presented in the Table 2

Table 2. Consumption of solvent-inhibitors recommended for wells of the Tuymazy oil production department.

Scale inhibitor	Well capacity, m^3/day	Reagent consumption per one treatment, m^3	Notes
СОНСОЛ-3003м СОНСОЛ-3001	1-5	0,025	Inhibitor consumption and treatment frequency is specified on the basis of field data, however, at least once a month
	5-15	0,050	
	15-25	0,050	
	25-50	0,100	
	50-100	0,150	
	100-200	0,200	

4. CONCLUSIONS

It was established that use of scale inhibitors considered in this paper allows not only removing the already formed carbonate scale but preventing formation thereof due to pH reduction.

5. SUMMARY

Thus, on the basis of calculations the conclusion may be drawn that by constant inhibiting the minimum inhibitor consumption is achieved. The prevention methods shall be used rather than scale removing ones.

CONFLICT OF INTERESTS

The author confirms that the data provided does not contain the conflict of interests.

ACKNOWLEDGMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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