Analysis of the technology of intensifying oil production through the bottomhole formation zone treatment in the Potochnoe field

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Abstract. The article aims at reviewing the effectiveness of the technology application to intensify production through the bottomhole formation zone treatment in the Potochnoe field. These technologies are becoming necessary measures if there is a possibility of dissolving rock or items that are deferred and reduce permeability. When carrying out any treatment of a bottomhole formation zone, we require a scientific approach to the selection of reagents that takes into account all terms of the collector and the containing fluid. The results presented in this paper are used when planning and implementing the intensification technologies of oil production through the bottomhole formation zone treatment in the field. There are also analyzed the laboratory tests typical for the conditions being similar to the Potochnoe field. There were considered the core samples from Urevskoye (facility UV1, AB_{13} and Ach_2) and Severo-Potochnoe (facility $БВ_6$) fields, and, accordingly, the impact of reagents on them. It was revealed that the reagent Altinex/1.2 has a low corrosion activity in the formation conditions, meets the requirements for the share and stabilization of iron, for compatibility with water, and is fully appropriate under the operating conditions of the Potochnoe field. The article discusses the effectiveness of technologies and makeups separately at the facilities for which the recommended makeups were composed taking into account the compatibility of the reagents with formation water, the rate of core solubility and compatibility with oil.

1. Introduction

The technology of intensifying oil production through the bottomhole formation zone (BHFZ) treatment is a common technology of enhanced oil recovery which allows increasing the treatment coverage in the development of inhomogeneous formation structures with numerous areas being not washed with water. The existing experience shows that the bottomhole well zone treatment, accompanying the reservoir treatment, substantially increases the oil recovery [1]. This benefit can be obtained by treating the formation in general through hydrodynamic, thermal, physical and chemical methods.

The probability of increasing the formation fluid production is significantly advanced when using the new high-performance equipment and technologies. Physical and chemical effects provides both filter cake removal and dissolution of asphaltene-resin-paraffin deposits in the bottomhole formation

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zone and improves the performance of low-productive formations, stacked in reservoirs with the clay minerals content due to the recovery of the formation properties through cleaning and expanding existing channels and creating new ones, stabilizing the bottomhole formation zone at the remote sites and throughout the perforated section of the formation.

2. Methods and materials

The obtained results, discussed in the article, are justified through using methods approximating as much as possible commercial conditions for testing makeups on the cores, and through analysing the data acquired in the field before and after the technology implementation. When processing the field data, the well-known and proven methods of analysis through computers were widely used. The developed recommendations passed field-testing with positive technological effect.

The results presented in this paper are used when planning and implementing the intensification technologies of oil production through the bottomhole formation zone treatment in the Potochnoe field.

3. Results and discussion

Let us consider the results of implementing the production intensification technologies through the bottomhole formation zone treatment in the Potochnoe field [2].

From the beginning of developing the development wells in the Potochnoe field facilities, there were conducted 216 well operations (WO) on BHT. They include 125 WOs in operating wells, 1 WO in a drilled well, 50 WOs in nonoperating wells, 21 WOs in idled wells, 19 WOs in pressure-observation wells.

The success of the operations amounted to 87 %, the cumulative incremental oil production – 288.05 kt, the average duration of the benefit - 275 days, the average incremental oil rate - 5.2 t/day, the efficiency - 1334 tons/WO or 5.1 t/day. The benefit lasts in 31 wells treated from 2009 to 2011.

As it can be seen in figure 1, the largest number of activities was performed in 2011, 2010 and 2009 (39, 33, and 32 treatments, respectively). In 1984, 1985, 1986, 1989, 1992, 1993, 1995, 1996 the BHTs were not conducted. The maximum volume of incremental oil production was received in 2010 – 56.2 thousand tons, and in 1983 and 1990 there were received no incremental oil volumes.

When carrying out the BHT in the Potochnoe field there were applied the following technologies and makeups (figure 2):

- technologies of BHT "Helium" - 119 WOs;
- hydrochloric acid treatment (HAT) - 36 WOs;
- mud acid treatment (MAT) - 32 WOs;
- acid microemulsion (AME) - 8 WOs;
- makeup "Altinex" - 7 WOs;
– hydro-vibration effect (HVE) – 2 WOs;
- makeup "Axis" - 1 WO;
– VDCI – 1 WO;

The data from the 10 wells on the used makeups are just missing.

Thus, the greatest number of treatments was carried out on the facilities AB_{1-2} and Ach - 112 and 52 WOs respectively, the next group includes the facilities BV_6, BV_8 and BV_{10} which underwent 27, 14 and 9 WOs respectively (figure 3). The facilities BV_5 and UV_1 underwent 1 WO per each.

In general, the volume of incremental oil production corresponds to the number of activities undertaken, there is almost a direct correlation between these parameters [3].

36 wells after conducting the BHT faced optimizing bottomhole pumping equipment (BHPE). On the basis of calculating the benefits from equipment change and chemical bottomhole zone treatment, it was found that:

– for 4 wells (No. 937, 878N, 104N, 892N), the operational benefit was acquired from the BHPE optimization;

– for 11 wells (No. 1677, 1729, 589, 101, 2701N, 949, 137N, 1688B, 1677, 456, 198), the benefit is of a composite nature (the change of BHPE+BHT);

– for 21 wells (No. 780, 972N, 408N, 1962N, 987, 1833N, 730T, 130N, 456, 516, 1927N, 898N, 105B, 1926N, 108T, 2203, 958, 108T, 345N, 105N, 1795), the benefit is only caused by the chemical treatment of the BHFZ.

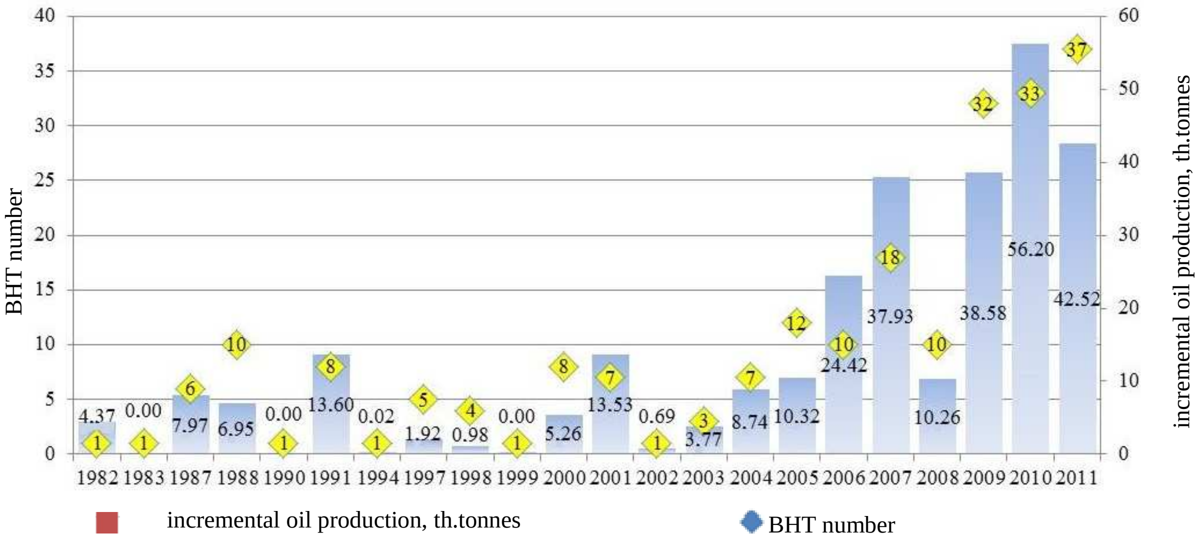

Figure 1. The distribution of the incremental oil production and the number of events by years

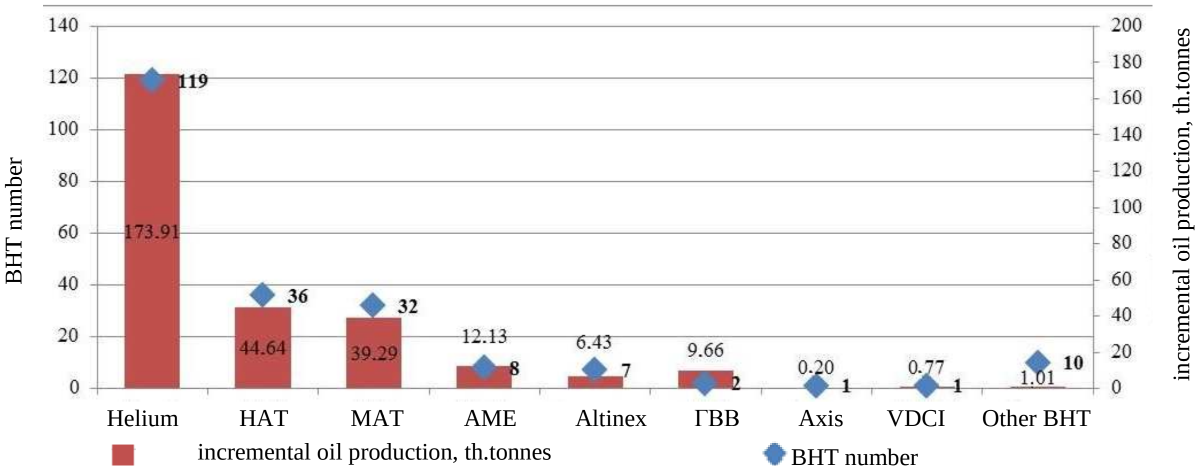

Figure 2. The distribution of the incremental oil production and the number of events by technologies/makeups

The result of comparing the operating wells modes before and after the BHT states:

– for 195 wells, the incremental liquid rate amounted from 2 to 344.29 t/day; for 8 wells, the incremental liquid rate has slightly changed (up to 2 t/day), 13 wells produced a reduced rate. Thus, from the point of the incremental liquid rate, the success of the treatments was 90 %;

– for 151 wells, the water content increased to 99 %; for 10 wells, it has not changed; and for 55 wells, a decline in water content was indicated up to 52 %. Talking about the reasons for the decline in water content is not possible in the absence of research of the flow profile before/after treatments. It is supposed that the water content declined as a result of changes in the flow profile [4].

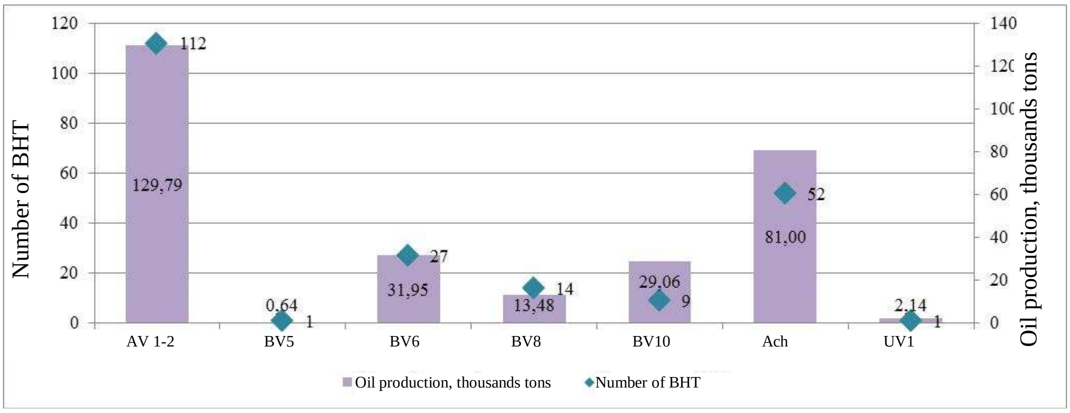

Figure 3. The distribution of the incremental oil production and the number of events by facilities

During the period of 1982-2006, 27 wells of the Potochnoe field produced an incremental oil rate less than 1 t/day for the following reasons: waterflooding in the high permeability sublayer with bottom or injected water; clogging of the pore volume with reaction products; well casing deformation; delay in repair works [5, 6].

During 2007-2011, holding HMO resulted in the fact that incremental oil rate has not been obtained only in one well. This well had been idled from September 1988 until June 2008 when it was again put into operation with an average production of 1.8 tonnes after implementing pumping equipment repair and FGT. The main reason for the low success of this event is the risk of water outburst from the border zone via high permeable sublayers, after installing a BHP of a larger size at the well. Water outburst is evident from a steady-state high dynamic level in the well prior to its disconnection (901 m) which is higher than in the first month after the BHT implementation (1430 m).

The distribution of process parameters in relation to the technology implementation in the Potochnoe field is shown in Table 1.

During the laboratory tests for the conditions similar to the Potochnoe field, there were examined the core samples from the Urevskoye (facilities UV_1, AV_1^3 and Ach_2) and the Severo-Potochnoye (facility BV_6) fields, and accordingly, the reagent influence on them (table 2).

The most informative and closest to the commercial conditions are the methods of testing makeups on the cores [7].

To assess acid makeups we determined their compatibility with formation water, corrosiveness, core solubility, stabilization of iron ions, prevention of the acid-oil emulsion formation, ARPD dispersion, high permeability, increase in the relative core permeability.

Table 1. The distribution of process parameters in relation to the technology implementation in the Potochnoe field objects

Facility		Technology and makeups								
		Helium	HAT	MAT	AME	Altinex	HVE	Axis	VDCI	Other BHT
AB_{1-2}	Q_{iop}	75.69	23.50	21.60	8.12	0.06	-	0.20	-	0.62
	N	64	18	16	5	1	-	1	-	7
	τ	285	277	257	507	15	-	72	-	87
	$\Delta q_{НК}$	5.71	3.49	2.84	4.14	4.20	-	2.35	-	-5.03
	K_{sp}	1.18	1.31	1.35	1.62	0.06	-	0.2	-	0.09
BV_5	Q_{iop}	-	-	0.64	-	-	-	-	-	-
	N	-	-	1	-	-	-	-	-	-
	τ	-	-	174	-	-	-	-	-	-
	$\Delta q_{НК}$	-	-	7.38	-	-	-	-	-	-
	K_{sp}	-	-		-	-	-	-	-	-

BV_6	Q_{iop}	12.84	7.74	9.21	2.15	-	-	-	-	0.00
	N	10	7	7	2	-	-	-	-	1
	τ	407	336	209	324	-	-	-	-	-
	$\Delta q_{\text{НК}}$	4.74	1.97	8.12	7.21	-	-	-	-	-0.97
	K_{sp}	1.28	1.11	1.32	1.08	-	-	-	-	
BV_8	Q_{iop}	3.74	0.45	7.04	1.86	-	-	-	-	0.39
	N	2	2	7	1	-	-	-	-	2
	τ	473	164	185	754	-	-	-	-	57
	$\Delta q_{\text{НК}}$	3.61	-18.03	7.50	2.00	-	-	-	-	1.68
	K_{sp}	1.87	0.22	1.01	1.86	-	-	-	-	0.19
BV_{10}	Q_{iop}	20.79	3.92	0.81	-	3.54	-	-	-	-
	N	5	1	1	-	2	-	-	-	-
	τ	609	182	104	-	170	-	-	-	-
	$\Delta q_{\text{НК}}$	10.73	42.21	4.70	-	7.84	-	-	-	-
	K_{sp}	4.16	3.92	0.81	-	1.77	-	-	-	-
Ach	Q_{iop}	60.85	6.89	-	-	2.83	9.66	-	0.77	-
	N	38	7	-	-	4	2	-	1	-
	τ	223	250	-	-	134	440	-	130	-
	$\Delta q_{\text{НК}}$	7.66	3.84	-	-	7.04	12.43	-	6.75	-
	K_{sp}	1.60	0.98	-	-	0.71	4.83	-	0.77	-
UV_1	Q_{iop}	-	2.14	-	-	-	-	-	-	-
	N	-	1	-	-	-	-	-	-	-
	τ	-	375	-	-	-	-	-	-	-
	$\Delta q_{\text{НК}}$	-	6	-	-	-	-	-	-	-
	K_{sp}	-		-	-	-	-	-	-	-

where $_{Q}$iop – incremental oil production, th. tonnes; N – the number of BHT; τ - duration of the benefit, days; $\Delta q_{\text{НК}}$ - incremental oil rate, t/day; K_{sp}- specific benefit, th. tonnes/WO.

The basis of all submitted acid makeups is water solutions of hydrochloric acid. In composition, the analyzed makeups can be divided into three groups:

- hydrochloric acid - Aldinol 20P, Altinex/1.1 and Altinex/1.2;
- mud acid – HCl_{inh}, Altinex/1.2 +1%HF;
- hydrochloric acid with the addition of acetic acid – Flaksokor 210.

Table 2. Characteristics of acid makeups

Reagent	Makeup
HCl inhibited	hydrochloric acid, hydrofluoric acid, corrosion inhibitor VNPP-2V
Aldinol 20P	hydrochloric acid, polyatomic alcohols, surfactants, corrosion inhibitor
Altinex/1.1	hydrochloric acid, corrosion inhibitor, scale inhibitor, demulsifier, solvent VR25
Altinex/1.2	
Altinex/1.2, HF	hydrochloric acid, scale inhibitor, corrosion inhibitor, demulsifier, solvent VR25, HF 1%
Flaksokor 210	hydrochloric acid, acetic acid, surfactants, corrosion inhibitor
Flaksokor 210, HBF_4	

Relatively good results were obtained for the reagent Altinex/1.2. It has a low corrosion activity in the formation conditions, meets the requirements for the share and stabilization of iron, for compatibility with water, and is fully appropriate under the operating conditions of the Potochnoe field.

4. Conclusion

The facility UV_1 is recommended to use complex makeups made of Altinex/1.2 with the addition of hydrofluoric acid (no more than 1%), but with a delay in response. In the wells with high carbonate content or carbonate deposits, as well as capping a well through calcium chloride, it is recommended to use this makeup without hydrofluoric acid [9, 10].

The facility Ach_2 is recommended to use the makeup Altinex/1.2 in a pure form without introducing hydrofluoric acid. At this facility, the acid treatment is recommended to apply without delay in response.

The most efficiently working makeup for the facility AV_1^3 is Altinex/1.2 with the addition of 1% hydrofluoric acid. This reagent is compatible with the formation water, and the core solubility number is above average [11]. The base solution and the worked-out makeup are compatible with oil.

For the formation BV_6, it is possible to use makeups Altinex/1.2 and Flaksokor 210. These makeups are recommended as basic. In the wells with high clay content, the introduction of hydrofluoric acid in the amount of 1% or 3% CFU in these makeups becomes possible.

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