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ANALYSIS OF THE CURRENT STATE OF THE ZAPADNO-MALOBALYKSKOYE OIL FIELD DEVELOPMENT (KHMAO-YUGRA)

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The full-scale development of the Zapadno-Malobalykskoe oil field began in 1999, with produced water re-injection being started in 2000. Since then, the production history has been determined by wells of highly porous and permeable development targets (AS_4, BS_2, BS_8). Over the first four years, oil and fluid production was marked by its low rate due to the very moderate field development of the main BS_8 formation. Having reached its peak in 2005, the oil production stabilized at the level of 2.4 to 2.6 million tons up to 2007, with the rate of putting wells on production significantly reducing from 45 to 10 to 20 wells per year (Fig. 1) [3].

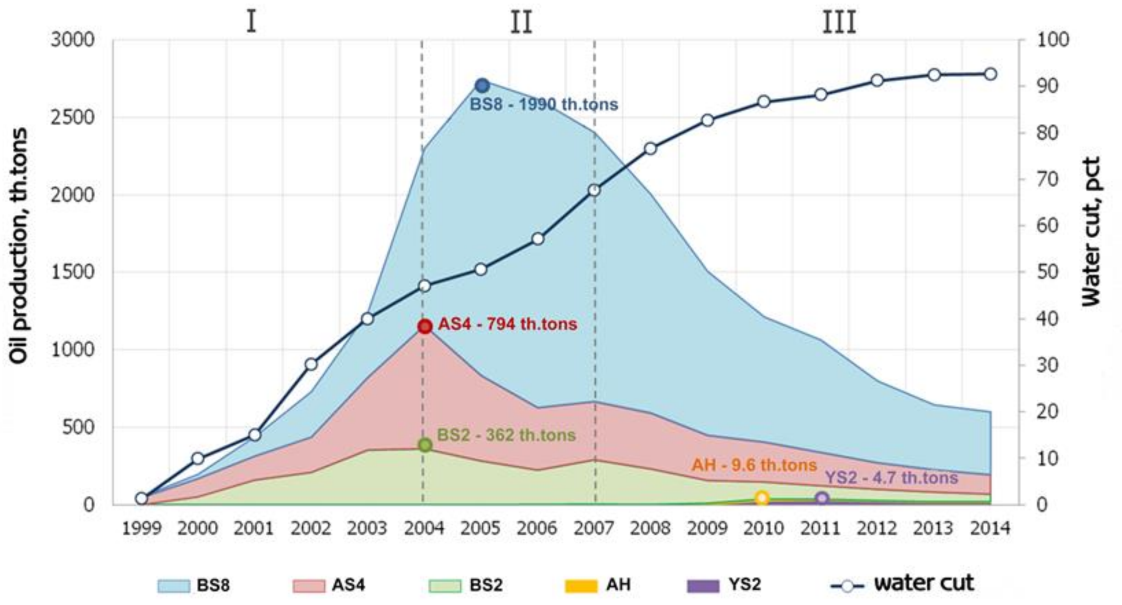

Fig. 1 Production history (1999-2014) of the Zapadno-Malobalykskoe development targets AS_4, BS_2, BS_8

During the entire field development period, the water cut was expanding at a high rate: 6-10% per year reaching 82.7% in 2009, with the withdrawal of 39.6% of recoverable reserves in compliance with the industrial categories. Over 2010-2014, well drilling at the main BS_8 formation enabled water cut rate to be stabilized at 0.5-2.0%. In 2014, the fractional water content amounted to 92.6 %, with only 46.6% of all recoverable oil reserves being withdrawn. The main reason for the withdrawals discrepancy is the advancing water production of the main development target AS_4 (extensive self-induced fracturing network) and BS_2 (putting into operation under-saturated oil bottom intervals) [1].

Since the production history began, the field has produced 20,509 th.tonnes of oil and 88,274 th.tonnes of fluids, with the accumulated water injection amounted to 91,617 thousand cubic meters. 46.6% of them were drawn from the initial recoverable reserves. Remaining recoverable reserves are estimated to 23,492 th.tonnes. Reserves-to-production ratio is 39 years.

The formation AS4 is represented by three oil deposits. Almost all recoverable oil reserves are concentrated in the main deposit, that is 99.4% (9,059 th.tonnes). The formation well stock has been developed by 70%. Well drilling is planned in the marginal areas of the main deposit. The current 3-line drive system is aimed at maintaining reservoir pressure [2]

The formation AS4 is characterized by high reservoir porosity and permeability, according to A.A. Khanin's classification it can be referred to the Group III. In order to intensify the wells production rate, formation hydraulic fracturing was applied. The amplitude fluid rate without fracking and post-fracking fluid rate vary from 30 to 95 tpd and from 240 to 450 tpd, respectively.

The formation development state is characterized by the following indicators: withdrawal from initial recoverable reserves is 51.4%; water production amounts to 94.8%; and recoverable reserves-to-production ratio is 36 years. The specific oil production per operating well accounts for 170 th.tonnes; remaining recoverable reserves per operating well are 108.1 th.tonnes. The analysis of current trends reflects the low efficiency of the development process. According to the estimations, the expected oil recovery factor will be 0.24 fr.unit, with the approved oil recovery factor of 0.398 fr.unit. Non-optimal injection drives (systematic excessive rock fracturing pressure - 330 atm) initiated the self-induced fracturing network contributing to a rapid growth of water cut [1].

Factors complicating the oil reserves recovery:

– drilling induced fractures in water injection wells and low sweep efficiency in water cut;

Technological advancements involve:

– water injection optimization into the reservoir (limitation of the injection pressure) will allow reducing the water cut rate and optimizing conformance control activities;
– well network optimization: horizontal sidetracking in the remaining reserves zones;
– well re-completion of the underlying horizons.

The formation BS2. There are four formations and only three of them are under development. They are characterized by high reservoir rock porosity and permeability. Most of the recoverable reserves are concentrated in the deposits No. 3 (Vrez) 70.5% (4,938 th.tonnes). The formation well stock has been developed by 63%. The remaining wells aimed to be drilled are concentrated in the deposit No.1 (a well 445), well re-completion from the overlying AC4 formation to the deposits No 2, 4 are also planned. The current development system is a 3-line drive system aimed at maintaining reservoir pressure [2].

The formation BS2 is characterized by high reservoir porosity and permeability. According to A.A. Khanin's classification, it can be referred to Group III. Fracking operations are preferably being applied for most production wells. The amplitude fluid rate without fracking and post-fracking fluid rate vary from 40 to 90 tpd and from 200 to 500 tpd, respectively.

Withdrawal from the initial recoverable reserves is 38.7% (for the deposit No 3 (Vrez) amounts 52%), with water cut of 97.1%. Fracking operations are preferably being applied for most production wells. The specific oil production per operating well is 150 th.tonnes. Remaining recoverable reserves per operating well amount to 236.1 th.tonnes. The reserves-to-production ratio is 88 years and this fact also indicates unfavorable trends actively manifested at the present time. According to the integrated calculations for water-oil displacement, the expected oil recovery factor will only reach 0.164 fr.unit, while the approved oil recovery factor is expected to 0.393 fr.unit [1].

Factors complicating the reserves recovery:

– low quality of mobile oil; reduction of oil saturation to the bottom intervals~~;~~
– free water content in the bottom part; the mass application of hydraulic fracturing within the producing well stock;
– the spread of fracturing cracks into the bottom intervals characterized by reduced oil saturation.

Technological advancements involve:

– re-perforation of the roofing intervals;
– horizontal sidetracking in the roofing intervals.

The formation BS8 is the main in terms of the current reserves, with about 90% of the oil capacity. The formation well stock has been developed by 63%. Planned well re-completion from the overlying formation which concentrated in the northern deposit (a well 24P), which has currently not been put into development yet [2].

The formation BS8 is characterized by high reservoir porosity and permeability. According to the classification of A.A. Khanin's it can be referred to Group III. In order to increase the production rate, fracturing operations have mostly been applied. The amplitude fluid rate without fracking and post-fracking fluid rate vary from 30 to 95 tpd and from 240 to 450 tpd, respectively.

With the 55 ha per well of the well spacing density, the withdrawal from initial recoverable reserves amounts 65% (the drilled area) and water cut - 90%. The current development system is a five-spot drive system aimed at maintaining reservoir pressure. The specific oil production per operating well is 165 th.tonnes. Remaining recoverable reserves per operating well are 91 th.tonnes. Reserves-to-production ratio is 22 years. The analysis of the current trends reflects the high efficiency of the formation development. According to the estimates, the expected oil recovery factor will be 0.457 fr.unit (the approved oil recovery factor is 0.516 fr.unit), with the vertical sweep efficiency of 0.746 fr.unit (the approved vertical sweep efficiency 0.845 fr.unit) [1].

Factors complicating the reserves recovery:

– well integrity study (30% of the studied production and injection wells are complicated by the cross flows behind the casing and production casing leaks);
– the share of inefficient injection is 15% and low well spacing density.

Technological advancements involve:

– restoration of hydraulic bond of the injection wells for effective regulation of injection volumes;
– extensive application of the conformance control, formation pressure maintenance regulation;
– drilling new horizontal wells and horizontal sidetracking in the current reserves.

Thus, the deposit has been developed at a moderate pace, the current situation cannot be regarded as satisfactory. The water cut of the main formations reached 93%, with 46.6% withdrawal from initial recoverable reserves. Rehabilitation of the drilled area will require a large-scale program of well intervention operations. For the main formations (AS4, BS2, BS8), key compensatory activities are horizontal sidetracking into remaining reserves, water injection optimization (reduction of injection pressure, injection wells increase, application of the conformance control,) liquidation of cross flows behind the casing and production casing leaks. The approved oil recovery can be achieved by large volumes of produced water.

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SYNTHESIS OF ZEOLITE MATERIALS USING A TWO-STEPS METHOD AND STUDY OF ITS PROPERTIES FOR FURTHER USE IN FLUID CATALYTIC CRACKING (FCC)

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Zeolites are porous aluminosilicates materials that have valuable properties for industry, being used mainly in adsorption and catalysis. The synthesis of zeolites is performed using sources of aluminum (Al) and silicon (Si) in contact with a strong base, sodium hydroxide (NaOH), for example. The reaction extracts the Si and Al minerals from the solution and a reorganization of the atoms, with the presence of sodium cations (Na^+) occurs. The composition of the materials present in the zeolite can be expressed as the following expression [1-3, 5]:

$$M_{\frac{x}{y}}\left\{[Al_2O_3]_x[SiO_2]_y\right\} * m\ H_2O \tag{1}$$

Where,
• M is an interchangeable cation or valence compensation cation n;
• m is the number of water molecules;
• x and y are the number of tetrahedra per unit cell of the corresponding oxide;
• x / y = Si / Al ratio, which can vary from 1 to infinity (Loewenstein's rule - which explains that the crystalline network cannot contain the type of Al-O-Al bonds) [2,4,6,8].

As can be seen, the Si/Al ratio is one of the most important parameters in the synthesis, since each zeolite has a specific range for its formation to be possible [3, 5, 7].

Currently, many materials become wastes and increase environmental problems. Some have a high concentration of Si and Al, and could be used in zeolite synthesis, for example. Among them, some that are valuable sources of minerals are ashes originated from combustion processes for power generation - rice husk and coal fly ashes [2,4].

Composed by 47 % to 65 % SiO_2 and 16 % to 29 % Al_2O_3 of mass, the coal fly ash is largely employed in the synthesis. In addition, the use of rice husk is possible, since they are composed primarily of silicon oxide (SiO_2), with more than 90%. Moreover, different materials that have high concentration of Si and Al, can also be used as raw materials for the synthesis [2, 6, 9].

Furthermore, it is also very important that the materials contain a small concentration of iron (Fe_2O_3) and calcium (CaO). In the synthesis reaction, if these two components are present in high quantities, the reaction between NaOH and Si and Al, will not be preferable. Since competitive reactions occur. Thus, turning impossible the synthesis of specific zeolites, as zeolite Y, to occur [4-6, 10].

Therefore, with the results obtained from x-ray fluorescence analysis data, it was possible to determine the main types of materials with quantified compositions of oxides that could be employed in the zeolite synthesis. The selected materials are Tomsk clay, rice husk ash, oat husk ash, Kuzbass, Seversk and Tomsk coal fly ashes [4, 7-10].

Once the zeolite is obtained, it is possible to transform it in a catalyst. Nowadays the most prominent zeolite is zeolite Y, because of the porosity and cationic exchange capacity. The materials listed above provide all the requirements for the zeolite two-step synthesis method. [3, 5, 7]

Mainly, zeolites can be synthesized from raw materials in two different process: one-step and two steps. The main difference between the methods is the intensity of the interaction between the ash and the base. Thus, the two-steps method is the first method with an addition of the hydrothermal fusion process, where ashes are fused with NaOH, for improvement of the interaction of the cations, and extraction of Si and Al from the ash into the system. [2-4, 8-10]

Moreover, within the optimization of the zeolite synthesis process in a two-steps method is possible to achieve higher specific surface area, and exchange capacities [1, 4, 9]. Furthermore, the main zeolite, as previously informed, used in the catalysis is the Zeolite Y; and the most available zeolites in the market use a variation of the zeolite Y, with different materials as for catalyst support. Therefore, following the synthesis and optimization of the zeolite two-steps method, the production of highly promising zeolites to be used as catalysts is enhanced [2, 9].

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