Analysis of geological and engineering measures effectiveness at Vyngayakhinskoe field

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Abstract. Vyngayakhinskoe is a multi-zone oil and gas field with hydrocarbon accumulation. It is characterized by reservoirs with low permeability and hard-to-recover reserves. In recent years Vyngayakhinskoe field has undergone a large number of geological and engineering intervention measures (GEM) that made it possible to reduce the rate of decline and maintain the production level of 1 million ton a year [1-2]. The performed geological and engineering measures (GEM) show the effectiveness of such efforts as drilling of dual lateral and horizontal wells, as well as hydraulic fracturing (HF).

1. Introduction.
A strategy of oil fields development is ensured by qualitative and accident-free operation of producing and injection wells. Wells construction and their subsequent operation result in bottom-hole formation zone damage (BFZ) and can complicate the operation of producing wells.

The main reasons for the change in permeability and porosity of a reservoir are colmatation of the reservoir by mud filtrates, changes in thermobaric conditions and physico-chemical characteristics of fluids as a result of primary and secondary drilling. The measures that restore the reservoir condition and eliminate the positive skin factor are of particular importance in this respect.

2. Methods and techniques.
Vyngayakhinskoye oil and gas field is located in the Purovsky oil and gas bearing area of Western Siberia. It is territorially within the confines of the local structure of the same name that complicates the northern part of the Vyngayakhinsky bank. The field is a meridial elongated fold in structure and has an angle inclination of a limb up to 2.5 ° in the west and 1.5 ° - in the east. The field applies to one of the largest multi-layer reservoirs.

Vyngayakhinskoye field was involved in oil and gas operations in 1986. Despite a significant amount of remaining reserves, the current recovery rate is low [1]. The main field development target is BP11 which accounts for 36% of the recoverable reserves of the field as a whole. At the field, a considerable proportion of the well stock has been taken out of service (an idle well stock was more than 60%) due to the water cut of the produced fluids - more than 85%. About 64% of remaining recoverable reserves of oil (RRR) are concentrated under the drilled stock. Various research and development projects (RDP) were applied to increase the well production rate as well as the oil recovery rate (ORR).

Engineering intervention measures include drilling of horizontal wells (HW), simulation methods,
including physicochemical treatment of the bottom-hole formation zone (BFZ), hydraulic fracturing (HF), sidetracking (ST) and horizontal sidetracking (HS), wells transfer from one facility to another, reservoir commingling, the optimization of the well operating modes [3-7]. The following measures were also applied: forced withdrawals (FW), well servicing (WS), conformance control (CC) using different compositions, and others [8-12]. According to available data about 1830 well, interventions were carried out within 2001 - 2016. The total additional oil production from these activities amounts to 8,237.8 thousand tones of oil, or 54.1% of the total production (15,231.8 thousand tones) for the period in question, taking into account the carryover effect of the previous years.

The dynamics of the actual output and base oil production by the years of operation at the Vyngayakhinskoye field is presented in Figure 1. It depends on and correlates well with the number of geological and engineering measures carried out at the field.

Figure 1. The dynamics of the actual output and base oil production dependent by GEM by the years of operation at the Vyngayakhinskoye field

The types of geological and engineering measures carried out at the Vyngayakhinskoye field from 2001 to 2016 and additional oil production from operational facilities are presented respectively in Figures 2 and 3.

The majority of geological and engineering measures performed for the period of 2001-2016 makes 66% or 1208 operations that account for the BP11 development (due to the large number of production wells). 17.6% of GEM accounts for BP12, 10.8% - for U1, and 3.3% and 2.3% - for BP16 and BP17 respectively.
The production volume of additional oil is not associated with the number of GEM performed. At the BP11, 3366.1 thousand tons of additional oil was produced mainly due to drilling of horizontal wells and hydraulic fracturing. At the BP12, the additional oil production was 2462.1 thousand tons due to perforation and hydraulic fracturing. At the U1, the additional oil production amounted to 1988.2 thousand tons that makes 24.1% of perforations, hydraulic fracturing and sidetracking as a whole. The BP16 facility produced 370.9 thousand tons or 4.5% of additional oil while the BP17 - 50.5 thousand tons or 0.6% of additional oil due to the use of various perforating methods (Table 1).
Table 1. Geological engineering measures and additional oil production volume

| GEM type/reservoir | Number of well-operations | Additional oil production, thousand tons |
|--------------------|---------------------------|------------------------------------------|
|                    | BP11 BP12 BP16 BP17 u1 | Total BP11 BP12 BP16 BP17 u1 Total       |
| Horizontal well drilling | 42 9 19 2 72 881 122.4 287.3 60.4 | 1351.1 |
| Dual lateral well drilling | 13 | 13 299 | 299 |
| Sidetracking + horizontal sidetracking | 23 20 9 2 22 76 242.5 91.6 47.6 2.2 | 185.6 569.5 |
| Hydraulic fracturing | 238 62 8 26 20 354 1405.7 873.2 24.3 36.5 368.5 | 2708.2 |
| Bottom hole formation zone treatment | 95 71 4 7 63 240 39.7 22.3 0.4 2.9 | 51.2 116.5 |
| Conformance control | 189 58 18 | 19 284 134.7 52.1 10.3 | 16.6 213.7 |
| Perforating methods | 57 57 1 3 60 178 73.5 1251.5 0.2 | 8.3 1298 2631.5 |
| Optimization, forced withdrawals | 63 19 | 82 22.1 5.3 | 27.4 |
| Well servicing | 2 | 2 0.5 | 0.5 |
| Others | 486 26 1 5 11 529 267.4 43.7 0.8 0.6 7.9 | 320.4 |
| Total | 1208 322 60 43 197 1830 3366.1 2462.1 370.9 50.5 1988.2 | 8237.8 |

Table 2. Additional oil production in responding wells for one well operation

| Geological engineering measures type/reservoir | Additional oil production for one well operation, thousand tons |
|-----------------------------------------------|----------------------------------------------------------------|
|                                               | BP11 BP12 BP16 BP17 U1 |
| Horizontal well drilling                       | 20.98 13.60 15.12 0.00 30.20 |
| Dual lateral well drilling                     | 23.00 0.00 0.00 0.00 0.00 |
| Sidetracking + horizontal sidetracking        | 10.54 4.58 5.29 1.10 8.44 |
| Hydraulic fracturing                           | 5.91 14.08 3.04 1.40 18.43 |
| Bottom hole formation zone treatment           | 0.42 0.31 0.10 0.41 0.81 |
| Conformance control                            | 0.71 0.90 0.57 0.00 0.87 |
| Perforating methods                            | 1.29 21.96 0.20 2.77 21.63 |
| Optimization, forced withdrawals               | 0.35 0.28 0.00 0.00 0.00 |
| Well servicing                                 | 0.25 0.00 0.00 0.00 0.00 |
| Others                                         | 0.55 1.68 0.80 0.12 0.72 |

When assessing all the geological and engineering measures for the period of 2001-2016, the map of the remaining recoverable reserves is considered to be the most informative. The more the value of remaining recoverable reserves per well is, the more effective the applied measures are. The fact is
confirmed by the effectiveness of every well operation. Additional oil production for each well operation is shown in Table 2.

Horizontal and dual lateral wells can be verified as the most effective ones. Their additional oil production amounted to 30 thousand tons per one well operation, which is explained by the increase in the drainage area. Perforating methods and hydraulic fracturing are also highly effective, which is associated with better reservoir characteristics of the BP12 and U1.

3. Conclusion

Vyngayakhinskoe oil field is a multi-zone oil and gas field with hydrocarbon accumulation. Its reservoirs are characterized by low permeability and hard-to-recover reserves. In recent years Vyngayakhinskoe oil field has undergone a large number of geological and engineering intervention measures that made it possible to reduce the rate of decline and maintain the production level of 1 million ton a year. The article analyses geological engineering measures and confirms their effectiveness, specifically pointing out hydraulic fracturing and perforating methods.

References

[1] LLC RC "NEFTEPROEKT" 2017 Addendum to the technological project for the development of the Vyngayakhinskoye gas and oil field of the Yamalo-Nenets Autonomous District
[2] Sitnikov A N, Asmandiyarov R N, Onegov A V 2017 Verification of remaining recoverable reserves in fields with low production forecast. PRP OIL. Periodical science and technology magazine of Gazprom Neft. 02 31-38
[3] Strekalov A V, Mulyavin S F, Filippov A I, Steshenko I G, Bazhenova O A, Kolev Z M, Cheban S E and Urvantsev R V 2018 The mechanism of reserve recovery during waterflooding. International Journal of Mechanical Engineering and Technology (IJMET) 9, 3 1007–1013
[4] Ruchkin A A, Mosunov A Y, Gorbunov E Y, Novozhilov V G 1997 Features of the reserves development and workplan methodology to limit water inflow into massive deposits of the AB4-5 layer in late stage of development. Oil Industry 10 33-37
[5] Mulyavin S F 2013 Scientific and methodological justification for the development of crude hydrocarbon deposits with hard-to-recover reserves. (Theses for a DSc degree. Tyumen)
[6] Shkryaba I T, Mulyavin S F, Kleshchenko I I, Kusakin V Yu 2016 Analysis of multi-stage hydraulic fracturing effectiveness in horizontal wells at the Vyngapurovskoye oil-gas condensate field. (Higher Educational Institution news “Neft i Gas”. Tyumen: TIU)
[7] Fonin A A, Zakirov N N 2017 Drilling optimization for the directional well of the Salym field. Proceedings of the international academic conference "The state, trends and current issues of oil and gas potential development of Western Siberia." (Tyumen, TIU, Tyumen branch of the Russian Academy of Natural Sciences) pp. 123-127
[8] Agzamov F A, Zakirov N N, Kleshchenko I I, at al. 2014 Technology of oil and gas drilling. Textbook for university students. - In 5 tons. (Tyumen, Tyumen State Oil and Gas University)
[9] Kryanev D Yu 2008 Methodological substantiation study of oil recovery enhancement methods with hard-to-recover reserves (by examples of Western Siberia deposits). (Theses for a DSc degree. Moscow)
[10] Jafarov I S, Boxerman A A, Leibin E L and others 2000 Effectiveness of integrated nonstationary influence technology on layers of Ermakovsky field. Oil Industry 9 65-68
[11] Fonin A A, Zakirov N N 2017 Statistical study of S&J well drilling in Samomskoye field. Proceedings of the international academic conference "The state, trends and current issues of oil and gas potential development of Western Siberia." (Tyumen, TIU, Tyumen branch of the Russian Academy of Natural Sciences)
[12] Zakirov N N, Mulyavin S F, Sarancha A V 2017 Results of indicator studies on J1 facility in Kholmistoye field. IOP Conference Series: Earth and Environmental Science 87