Analysis of development status and adjustment method of a block

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Abstract. Since a certain block was put into development, it has always put improving the injection production relationship and improving the ultimate recovery factor in the first place. Through a series of infill adjustment, supplement and extended drilling, the injection production relationship of single sand body has been gradually improved. In high water cut period, the remaining oil distribution has been quantified through joint multidisciplinary research, and the fluid production structure has been adjusted by combining the oil well injection, hole filling, drilling and other measures, Hard and stable production in high water cut stage is realized. However, due to the small scale of sand body development and fault development, the contradiction between single sand body injection and production is still prominent. From the perspective of development effect of Gaotaizi old area, compared with Xingnan development area, the degree of recovery at the same water bearing stage is obviously low, and the development effect is poor. At present, the comprehensive water cut has reached 92.77%, and the recovery percentage is only 28.05%. The research shall be based on the results of fine reservoir description, guided by the results of multidisciplinary research, and focus on the comprehensive analysis and sorting of the injection production relationship of single sand body through the re understanding of geology, so as to find the adjustment potential of supplement and injection conversion. Through the adjustment of the injection production system, increase the water injection well points, expand the swept volume, improve the degree of water drive control, so as to increase the formation pressure and improve the development effect of the block.

Key words: water drive control degree; Current situation of injection production; Single sand body.

1. Background and purpose of the thesis

An oilfield is a heterogeneous oilfield of continental fluvial delta sedimentation, mainly composed of straight distributary channel sand bodies. This type of sand body has small development scale, low drilling rate, strong heterogeneity on the plane, and low well pattern control. Due to the small scale of sand body development, fault development and imperfect injection production relationship of single sand body, the contradiction is prominent: Problem 1 is affected by the development characteristics of sand body, the contradiction between imperfect injection production relationship is prominent, with a large decline, and the adjustment is difficult; Problem 2 The formation pressure level of a certain block is low and the development effect is slightly low. Therefore, it is necessary to analyze the development status of a block and study the adjustment potential, optimize and implement the potential of the adjustment plan, and predict the single well productivity and effect. In order to increase the water injection well points, expand the swept volume, improve the water drive control degree, increase the formation pressure, improve the injection production relationship, and achieve the purpose of improving the block development effect.

2. Establish a reasonable number water ratio of oil wells

According to the injection production balance principle, under the condition that the injection production pressure difference is basically stable and the total number of wells in the oilfield is certain, the reasonable oil-water well number ratio to obtain the maximum liquid production of the oilfield is equal to the square root of the ratio of the water absorption index of the water injection well to the liquid production index of the oil well, namely:

$$Row=\sqrt{\frac{Jw}{Jl}}$$

Where Row is the reasonable ratio of oil wells to water wells, dimensionless Jw is the water absorption index of water wells, m^3/(d.Mpa); Jl - Fluid production index of oil well, m^3/(d.Mpa)

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3. Investigation and study on injection production status in a block

The oil-bearing area of a block is 47.8km2. As of December 2018, there are 559 oil wells, including 383 oil production wells and 176 water injection wells. The well pattern density is 11.69/km^2, and the oil-water well ratio is 2.2. Up to now, the cumulative crude oil production is 690.86 × 10^{4}t, accumulated water injection 4205.80 × 10^{4}t, cumulative injection production ratio 1.20, recovery percent 28.05%, oil recovery rate 0.28, and annual oil production 6.45 × 10^{4}t, the daily oil production of each single well is 0.84t/d, and the comprehensive water content is 92.77%. Affected by the development scale of faults and sand bodies in Gaotaizi old area, the contradiction between injection and production is outstanding. Seen from the water drive control degree table of different thickness levels, one-way and two-way connectivity is dominant, and the proportion of connected layers below two directions (including two directions) is 54.9%. The connectivity ratio of three-way sandstone is only 12.3%. From the water drive control degree table of the subarea, the water drive control degree of Block B is slightly higher than that of Block M, and the proportion of connectivity above three directions in a block is slightly lower. On the plane, an oilfield subdivides sedimentary microfacies, including distributary plain facies, which can be subdivided into channel sand, interriver thin layer sand, off surface reservoir and pinch out area. The inner front facies can be subdivided into underwater distributary channel sand, interdistributary thin layer sand, off surface reservoir and pinch out area. According to the size and shape of sand body distribution in each unit, the sand bodies of an oilfield can be divided into the following four types (see Table 1).

From the point of view of the degree of water drive control of oil layers in a block, the latter three sand bodies are relatively low in water drive control, which is the focus of treatment. From the perspective of water drive control degree in the subarea, the water drive control degree of sandstone in an old area and Block B is similar, and the unidirectional connection proportion is high; From the point of view of the degree of water drive control of oil layers, the degree of perfection of single sand bodies of different sedimentary types is also different. It is believed that there is still a certain potential to improve the injection production relationship of single sand bodies.

Table 1 Sedimentary Types of Oil Layers in an Old Area

Sand body classification	Number of units	Channel sand drilling rate (%)	Sedimentary unit
Straight distributary sand body with main belt	6	23.0	5，6，7，8a，9，,10
Straight distributary sand body without main belt	4	21.1	2a，3，4，,8b
Intermittent narrow strip straight distributary sand body	3	14.8	1b，2b，11
Stable distribution of sheet sand	2	7.3	1.1，1a

4. Single sand body potential analysis

For oil wells that have been perforated, the potential of single sand body injection and production is not perfect or only one direction is effective due to poor water well sand body, excessive well spacing, non perforated water wells, poor water absorption and other reasons. The potential can be tapped through water well fracturing, hole patching and other measures; For oil well perforation, if the water well is not perforated or there is no water well, it will lead to recovery without injection. The direction of tapping the potential is to supplement the well or increase the water injection well points. For the imperfect single sand body caused by interlayer interference, plane interference and intra layer interference, the potential can be tapped by means of subdivision adjustment of water wells, plane adjustment of oil wells and profile control of water wells. For the non injection and non production caused by the non perforated oil well and the non perforated water well, the injection and production relationship can be improved through the simultaneous perforation of oil and water wells; For non perforated oil wells and non water well type non injection and non production, water injection well points can be increased and the oil wells can be re perforated at the same time; If the oil well is not perforated, and there is a water well, and there is no production due to perforation, the oil well can be re perforated. Seen from the types of imperfect injection and mining in an old area (see Table 2), there are mainly four types: no injection and no mining, in layer, fault edge and water absorption difference. Since most of the non injection and non production layers are oil-water same layer without perforation of oil and water wells, such as PI8, PI9, PI10, PI11 and other sedimentary units, they are not analyzed. Fault edge, injection without mining and mining without injection are the key points of this injection production system adjustment.

Table 2 Imperfection of Single Sand Body in an Old Area

Potential type	Number of layers		Sandstone		Valid	
	Number of layers(Nos.)	Proportion (%)	thickness (m)	proportion (%)	thickness (m)	proportion (%)
Injection without mining	136	4.51	250.5	4.21	181.2	4.25
Mining without injection	368	12.19	639	10.74	451.1	10.57
No injection and no mining	296	9.81	471.2	7.92	320.3	7.51
Interlayer interference	338	11.20	386.5	6.50	185.5	4.35
Intraformative	637	21.11	1864.8	31.35	1528.6	35.83
Planar interference	286	9.48	356.6	5.99	173	4.05
Fault margin	609	20.18	1305.3	21.94	923.6	21.65
Isolated sand body	2	0.07	2.7	0.05	1.8	0.04
Riverside	214	7.09	517	8.69	415.5	9.74
Water absorption difference	59	1.95	56.6	0.95	31.4	0.74
other	73	2.42	98.4	1.65	54.7	1.28

5. Research on the adjustment mode of imperfect injection production of single sand body

5.1 Evaluation on the perfection degree of single sand body in a block and analysis on the cause of single sand body imperfection

In the late period of high water cut, the remaining oil is mainly distributed between wells, and the direction of improving oil recovery should be to find sand bodies or local enrichment zones in sand bodies, loss zones of sand bodies and well patterns, local remaining oil enrichment zones caused by fault shielding, and the remaining oil between wells that can not be used well despite well pattern control. For this reason, the first main means is to drill various types of scattered adjustment wells, which are used to improve the sand body injection and production system, and to excavate the remaining oil in the fault and sand body corners; Second, sidetracking horizontal wells, directional deviated wells, branch wells, etc. are used to exploit oil enrichment zones between wells, especially near oil wells due to changes in reservoir physical properties, and can also be used for oil retention areas caused by fault shielding; The third is to apply conventional sidetracking to renew wells to solve the problem of incomplete injection and production caused by various reasons.

Focusing on sorting out the single sand body injection production relationship in the well area near the fault, such as production without injection, production with less injection and more production, the well area with adjustment potential is classified, and effective adjustment measures are formulated to improve the injection production relationship and tap the residual potential.

5.2 Residual oil retention area near the fault

In the vicinity of faults, it is easy to form remaining oil enrichment areas. For this situation, in combination with the results of fine reservoir description and multidisciplinary research, additional wells are arranged at appropriate locations to tap the remaining potential of the oil layer.

For example, the well block A34-29 is located near the fault. The fault is relatively complex. The production of oil well A35-28 in the well block is low and no fault is encountered. The distance between the well A34-29 and the oil well A35-28 is 360 meters, and the remaining oil around the fault is large. Based on the results of fine reservoir description, the sand body development is predicted. In order to reduce the injection production well spacing and excavate the remaining oil in the river near the fault, it is proposed to arrange the supplemental oil well A34-28 on the connecting line between Well A35-S27 and Well A34-29, 200 meters away from Well A34-29. Based on the fine reservoir description results, the drilling thickness of the supplementary well is predicted. The drillable sandstone thickness is 11.2m, the effective thickness is 6.4m, and the recoverable reserves can be increased by 0.5158×10^4t.

6. Formulate adjustment ideas, implement the potential of adjustment plans, and demonstrate research methods

6.1 Adjustment of injection production relationship

In order to further improve the development effect of an old area, it is mainly to apply the results of fine reservoir description to find the supplementary potential in the well areas near the fault and with great changes in the development of sand bodies. At the same time, for the well areas with large ratio of oil wells to water wells and imperfect injection and production of single sand bodies in the plane, the injection and production relationship is improved by means of oil well conversion.

6.2 Formulate adjustment principles

1. For areas with no water injection direction or multiple well areas with less water injection and production, improve the injection production relationship of the well area by drilling supplementary wells or transferring oil wells to water injection;
2. For the well area with more injection and less production and lack of recovery well points, the injection production relationship in the well area shall be improved by drilling additional oil wells;

3. After re understanding the structure through combination of well and earthquake, for the well area where the injection production relationship changes greatly due to fault changes, the injection production relationship in the well area can be improved by drilling additional oil and water wells or transferring oil wells to injection;
4. The thickness of sandstone encountered during single well drilling of supplementary well shall not be less than 5.0m, and the effective thickness shall not be less than 1.0m;
5. To prevent casing damage, no water injection wells shall be arranged within 100m from the fault;
6. The transfer well shall be no less than 100m away from the fault, and the increased recoverable reserves shall be more than 1500t.

6.3 Implement adjustment potential, prepare adjustment plan and demonstrate it

After the well location is preliminarily determined, the drillable thickness of a single well shall be predicted in combination with the development of sand bodies in the supplementary well area, the production status of single sand bodies in the well group shall be analyzed in combination with the fine mapping results, and the initial water cut and productivity shall be predicted in combination with the multidisciplinary research results. Finally, the economic benefits of the single well shall be evaluated. Plan the well locations that meet the well layout requirements.
According to the above ideas, Gaotaizi Old Area has preliminarily determined 22 injection wells adjusted by the injection production system (see Table 3); 8 internal supplementary wells (see Table 4), including 5 oil wells and 3 water wells; Renew 3 wells; There are 33 wells in total. After adjustment, the thickness ratio of connected sandstone in an old area has increased by 5.3 percentage points, the effective thickness ratio has increased by 3.8 percentage points, and the recoverable reserves are predicted to increase by 10.15×10^4t, the ratio of oil and water wells has reached 1.90 from 2.18, which is closer to the ideal value of 1.60, fully demonstrating the rationality of this research method.

Table 3 Well Layout Results of Injection Production System Adjustment Scheme

Number of design wells			Renewal well (water)	Average adjustable thickness of single well		Single well increase Recoverable reserves (10^4t)	Forecast Well productivity (t/d)	estimate Initial moisture content (%)
oil well	well	Subtotal		Sandstone (m)	Valid (m)			
5	3	8	3	8.3	6.0	0.46	2.2	70

Table 4 Statistics of Oil Well Reinjection in Injection Production System Adjustment Scheme

Number of wells converted from oil wells (mouth)	Average perforation thickness of single well		Increased recoverable reserves of single well (10^4t)	Estimated daily water injection of single well (m^3)
	Sandstone (m)	Effective (m)		
22	10.7	7.3	0.2294	30

7. Conclusion and understanding

1. The exploration of injection production balance principle is a necessary means to establish a reasonable well number ratio for reservoir development;
2. The application of reservoir related software, such as PREP2.0 and numerical simulation, assists in the implementation of adjustment potential and prediction of development indicators;
It is an effective way to improve the development effect of the block to excavate the remaining oil in the partial well block with imperfect injection production relationship through adjustment schemes such as supplement and injection conversion.

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