Analysis of factors affecting water injection effect of single sand body and research on control measures

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Abstract. According to the isotopic data annular monitoring, test results, well group control degree and other data, the water absorption status trend map of single sand body is manually drawn by using the oil well sealing method and the equal interval data interpolation method to determine the morphological distribution and dynamic connectivity of groundwater bodies. The relationship between the single sand body is confirmed, and the specific measures for coordinating and improving the single sand body are proposed.

Keywords: Single sand body, injection-production system, water absorption, state contact relationship, water injection effect

1. Introduction

With the improvement of water drive control, the ratio of oil and water wells in each set of well pattern tends to be reasonable, and still faces the contradiction of low formation pressure level and high proportion of low production and low efficiency wells. There are great differences in production conditions between different sand bodies with high control degree and low control degree. Adjust and coordinate the sand body with high degree of control through subdivision and redrawing, and improve the single sand body with low degree of control by means of hole patching, water plugging and stopping injection. By manually drawing the water absorption trend diagram of single sand body, establishing the process of coordinating and improving the injection production relationship of single sand body, identifying single sand body, determining the plane and spatial distribution form, studying the dynamic contact relationship, clarifying the dynamic contact relationship between single sand bodies, and determining the method to improve the water injection effect of single sand body.

2. Present situation and progress of new technologies

2.1 In-depth understanding of static data

There are two main factors affecting the production status of oil layer in water drive development [1]. One is uneven production in plane, and the other is prominent contradiction between layers. Through targeted adjustment, the production status of oil layer can be effectively improved.

2.1.1 Re-understanding of fault

There are 12 large and small faults in this block, and many faults are developed. The distribution of oil and water wells near the fault reaches 46%. Through the combined well-seismic structural modeling research in recent years, we have gained a new understanding of faults, and found that 5 faults have changed. Targeted plan adjustments were made for 36 wells near the fault, and the water cut was reduced by 1.3 percentage points.

2.1.2 Understanding of micro amplitude structure

By using the structural description method of small equal spacing, the understanding of local microstructure is clearer, and the high point of local microstructure is identified. According to the principle of hydrodynamics, the injected water is not easy to flow to the high point, and the resistance is greater. Therefore, in the process of water flooding development, there is a certain amount of residual oil in the oil wells with high points of local microstructure [2].

2.2 Re-understanding of the combination of dynamic and static data

Based on the careful analysis of monitoring data, dynamic change data and scheme adjustment effect, the main water inflow direction, main liquid producing horizon and high and low aquifers that mainly affect the development effect are identified and judged, so as to provide a basis for the development and adjustment of the oilfield.

Judging the main water inflow direction according to the influence of the switch well and the adjustment effect of the scheme, tracking the dynamic changes of the switch well area such as drilling shut-in area, shut-in area to be overhauled, shut-in area for other reasons (more than 6 months), comparing the adjustment effects of the well areas such as casing damage control injection, scheme precipitation and scheme water lifting, identifying the main water inflow direction of the oil producing wells in this well area, and combining the structure and structure in the fine geological research results according to the main factors affecting the water inflow direction. Summarize whether the main inflow direction is sedimentary facies controlled by the change of channel sand and lithology, or structural controlled by high injection and low production, low injection and high production, etc. [3], so as to guide the next scheme adjustment. According to the above judgment basis, a total of 95 wells were carefully analyzed, including drilling shut-in, overhaul shut-in, shut-in for other reasons and planned adjustment well area. The main water inflow directions of 61 wells were determined, and the dominant water injection directions of 30 well groups were defined.

Tab.1 Status table of effective wells around shut-in for various reasons

Shut in reason	Change Number of wells (mouth)	Valid Number of wells (well)	Change before and after well area				Identify the main incoming water direction		
			Nissan Fluid (t)	Daily oil production (t)	Containing water (%)	Submersion (m)	Well group (个)	Number of wells (口)	Sandstone (m)
Drill off	13	13	-18.2	-1.8	+0.03	-30	4	13	14.2
Overhaul close	3	4	-0.9	-0.2	+1.13	-47	3	3	2.1
Other shut in	9	7	-11.0	-4.8	+2.74	-44	6	9	2.4
Scheme adjustment	36	26	+65.7	+55.5	-2.0	-6	18	34	12.3
Total	61	112	-44.5	+0.1	+0.2	-92	30	74	10.6

2.3 Manually draw the trend chart of water absorption of single sand body

2.3.1 Data acquisition principle

(1) Isotope data. Use the absolute water absorption value of the monolayer test in the isotope data in the past 2 years, and use it quantitatively. The isotope data of the 23 wells in Block A in the past two years were collected, and the relative water absorption of each monolayer was summarized and analyzed. Based on the selected value data, the relative absolute water absorption was divided. In this way, the water absorption of each monolayer was determined. The calculation time is relatively uniform, which is convenient for comparative analysis.

(2) Annulus monitoring data. There are liquid production display data in the oil well annulus data in recent 3 years, which can be used qualitatively. The annulus test data of 14 ports in block a in recent 3 years are counted, the relative liquid production of each single layer is summarized and analyzed, and the relative absolute liquid production is divided based on the selected value data. In this way, the calculation time of liquid production of each single layer is relatively unified for comparative analysis. According to whether the single-layer liquid production is continuous, it is qualitatively judged as continuous production, intermittent production and non production, and this judgment is qualitatively used.

(3) Test result data. Divide according to the water absorption of the middle layer in the test data, and use it quantitatively. According to the test data, according to the effective thickness and permeability of single layer in subdivided intervals, the absolute water absorption is divided as the substitute data of this layer without isotope data.

(4) Well group control degree. Firstly, according to the well pattern relationship and well spacing, the ideal state of connectivity under static conditions is drawn in the well location map; secondly, the degree of static control is analyzed in combination with the sedimentary facies zone map and the sand body contact relationship; Adjust and reflect the situation, determine the dynamic connection between wells, and clarify the degree of control of each well in a single layer, and use it qualitatively.

2.3.2 Drawing principle

Map drawing is mainly based on the distribution pattern of the equivalent map of similar structures of underground water bodies, that is, when there is a large amount of water in the injection wells, the scope of influence is also larger, and there are equipotential areas in the water bodies between the injection wells. According to this, the distribution map of underground water bodies is manually drawn.

(1) Oil well edge sealing method. The injected water of the water injection well is considered to be produced in its adjacent production wells. From the relationship between injection and production, the water body at the water injection well has the largest potential energy, and the potential energy around the well point gradually decreases until the adjacent production wells decrease to zero, that is, it is produced. Therefore, it is considered that the injected water body is distributed in the underground with the injection well as the center, showing different shapes of contour distribution, and it is closed at the production well, and the contour is zero.

(2) The equidistant data interpolation method is adopted. From injection to production, the whole injected water body is reduced from the maximum to zero. In the area without well point data in the middle, the equidistant data

interpolation method is adopted. It is considered that the water body belongs to uniform equipotential distribution, that is, a considerable level of water body is distributed among the same areas.

2.3.3 Manual intervention correction principle

On the basis of the preliminarily drawn water absorption status map, taking into account the micro-amplitude structural drop, the development of interlayers within the layer and the changes of dynamic reflection, manual intervention is carried out to make corrections to make the water absorption status map more realistic.

(1) Micro amplitude structural drop. The structural drop in the block reaches 157m. The distribution of injected water between injection and production wells with high injection and low production, low injection and high production and injection and production wells with the same structural height is affected by the drop. Under the action of gravity, the injected water is easier to flow from high to low. According to experience, the structural drop increases exponentially with the impact. According to this relationship, The water injection distribution pattern of well points at different structural positions in the same single layer in the block is corrected to reduce the water injection distribution area to the high position of the structure and enlarge the water injection distribution area to the low position of the structure.

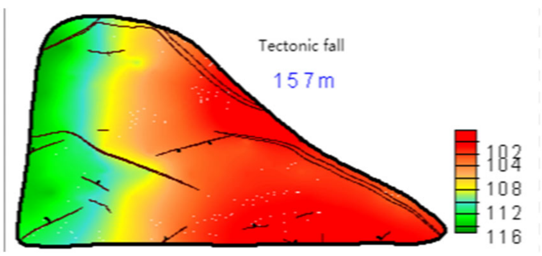

Fig.1 Equivalence map of structural drop of Block A

Tab.2 Situation table of the influence of slight structural drop

Tectonic fall(m)	<20	20~50	50~100	>100	……
Influence size	2%	4%	6%	12%	……

(2) Sandwich distribution within layers. The existence of interlayers affects the effective connection between injection and production wells. Due to the shielding of interlayers, the injection water distribution area of sand bodies with developed interlayers is smaller than that of sand bodies with no interlayers under the same conditions. The number increases exponentially with the effect size, that is, the more the dissection develops, the more the effect size increases exponentially.

Tab.3 Influence of interlayer in the layer

Number of interlayers in the layer (pieces)	1	2	3
Impact size	2%	4%	8%

(3) Dynamic reflection characteristics. In the static data analysis, there is a good connection relationship between injection and production wells, but the development status between wells is a gradual understanding process in the process of dynamic adjustment. Through the dynamic change reflection after scheme adjustment, the relationship between static data and dynamic reflection can be further confirmed, and the understanding of static data can be deepened on the basis of dynamic reflection.

2.3.4 Confirmation of the distribution of underground water bodies

According to the distribution state of the groundwater body shape drawn earlier, combined with the distribution shape of the sedimentary facies in this well area, it is determined whether the two tend to be consistent in shape, so as to confirm the single sand body type.

(1) Hydrodynamically consistent single sand body. If the shape of groundwater body is consistent with that of sedimentary facies, it is recognized as single sand body with consistent hydrodynamics. The adjustment between these single sand bodies is relatively easy, and the corresponding scheme adjustment can be implemented according to the current connection relationship.

(2) Re-understanding of single sand body by hydrodynamics. If the shape of underground water body does not match that of sedimentary facies, it will be identified as a single sand body with hydrodynamic recognition, which can be further subdivided into hydrodynamic enlarged single sand body and hydrodynamic reduced single sand body. If the shape of the drawn underground water body is larger than the sedimentary facies area of the well area, it is considered to be a hydrodynamically expanded single sand body. When implementing the scheme adjustment of this well area, more consideration can be given to the adjustment of the well location that was originally thought to be uncontrollable by the well group, and the remaining oil in this direction can be excavated. If the shape of the drawn underground water body is smaller than the sedimentary facies area of the well area, it is considered to be a single sand body with reduced hydrodynamics. This well area can better explain the inconsistency between the original dynamic and static data, and the adjustment of wells that are out of control should be avoided when making the plan, even if the adjustment is difficult to see the expected effect.

3. Adjustment method

3.1 Determine the method of coordinating and perfecting the injection production relationship of single sand body

According to the full understanding of the shape of groundwater body, this paper puts forward a targeted method to coordinate and improve the injection-production relationship of single sand body, that is, to coordinate and improve the single sand body with high control degree and the single sand body with low control degree. Give the preliminary opinions on coordinating and perfecting the injection-production relationship of single sand body, and improve the single sand body with low control degree. Mainly through measures to reform, adopt interval water plugging, single-layer hole plugging and selective fracturing, and coordinate and control the single sand body with high control degree. Mainly through scheme adjustment, adopt subdivision single card and interval periodic water injection. Through the above analysis, a total of 365 wells of oil and water wells have been adjusted, with an average daily oil increase of 0.3t per well and an increase of 10m in submergence.

Tab.4 Coordination and improvement of single sand body injection-production relationship plan adjustment table

classification total	Adjustment of water injection well (number of wells)									Production adjustment (well times)					add up to
	Measurement and tuning	to subdivide	Redraw	Fracture	Acidification	Fill hole	Renew	Overhaul	Subtotal	fracture	Fill hole	Small pump change	Adjusting parameters	Subtotal	
classification	36	28	24	20	25	4	2	19	158	25	17	15	150	207	365

3.2 Establish, coordinate and improve the injection production relationship process of single sand body

By confirming the degree of control, the division of single-layer water absorption, the application of fine geological results and the identification of dynamic reflection, the trend chart of water absorption status is drawn manually, and the trend chart of water absorption status of single sand body is revised by manual intervention according to micro-amplitude structural drop, sand body contact relationship, sandstone thickness difference, permeability ratio and interlayer distribution, the distribution status and dynamic connectivity of underground water body are determined, and the shape of single sand body is reconfirmed. On this basis, Put forward specific measures to coordinate and improve the single sand body with low control degree, mainly through measures transformation, adopting interval water plugging, single-layer hole plugging and selective fracturing, and coordinating the single sand body with high control degree, mainly through scheme adjustment, adopting subdivision single card and interval periodic water injection.

Tab.5 Coordinate and improve the injection production relationship process of single sand body

<table>
<tr><td colspan="10">Coordinate and improve the injection production relationship process of single sand body</td></tr>
<tr><td colspan="2">Confirmation of control degree</td><td colspan="3">Single layer water absorption splitting</td><td colspan="2">Fine geological achievements</td><td colspan="3">Dynamic reflection recognition</td></tr>
<tr><td>Static control degree</td><td>Dynamic control degree</td><td>Isotope absorption display</td><td>Annulus liquid production display</td><td>Water volume of test layer</td><td>Sand body shape distribution</td><td>Dynamic control degree</td><td>Main water absorption direction</td><td>Main liquid producing layer</td><td>Low aquifer level</td></tr>
<tr><td colspan="10">Manually draw the trend chart of water absorption of single sand body</td></tr>
<tr><td colspan="2">Microstructural drop</td><td colspan="2">Sand body contact relationship</td><td colspan="2">Thickness difference of sandstone</td><td colspan="2">permeability ratio</td><td colspan="2">Influence of interlayer distribution</td></tr>
<tr><td colspan="10">Trend chart of water absorption of single sand body corrected by manual intervention</td></tr>
<tr><td colspan="5">Groundwater distribution</td><td colspan="5">Dynamic connectivity</td></tr>
<tr><td colspan="10">Reconfirmation of single sand body morphology</td></tr>
<tr><td colspan="10">Coordinate and improve the treatment opinions of single sand body</td></tr>
<tr><td colspan="4">Sand body with high degree of coordination and control</td><td colspan="6">Single sand body with low degree of perfect control</td></tr>
<tr><td colspan="2">Subdivision redrawing</td><td colspan="2">Periodic water injection</td><td colspan="2">Water plugging</td><td colspan="2">Patching</td><td colspan="2">Stop injection</td></tr>
</table>

4. Conclusions

With the advancement of testing technology and the increase of dynamic and static data, the understanding of underground sand bodies is constantly changing; through the re-understanding of single underground sand bodies, the trend map of water absorption status of single sand bodies can be drawn to further clarify the characteristics of single sand bodies. form; determine the distribution state and dynamic connectivity of groundwater bodies so as to establish a perfect injection-production system adjustment system and improve the production status of the oil layer.

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