Analysis on water control and potential tapping of Gaotaizi oil layer in the west of central region

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Abstract. Gaotaizi oil layer in the west of central region is an example small well spacing area of Saertu Oilfield. The Gaotaizi oil layer in the west of the central region adopts the five-point area well pattern of 106m. With the development going deeper and deeper, the utilization degree of small well spacing area is low, large difference in plane pressure, test adjustment is difficult, the block water content of the block rises rapidly, and other issues are becoming increasingly prominent. To solve these problems, this paper is based on research on fine oil layer description, adjustment of injection-production structure by fine application, apply water control and tapping potential technology of narrow river channels, reinforce the intelligent research. The adjustment technology of water control and efficiency improvement and deep tapping potential in small well spacing area of water-driven Gaotaizi in Sazhong is formed. Effectively improve the development level of small well spacing area, and achieve the effect of "control water content, control it not to decrease progressively".

1. Overview of the study region
The west of the central region is located in the middle Sazhong development zone of Saertu Oilfield, with an oil-bearing area of 9.04km². The geological reserves of Gaotaizi oil layer in the west of central region are 4876.6×10⁴t, among which the geological reserves of the oil layers inside the surface are 3485.2×10⁴t, while the geological reserves of the oil layers outside the surface are 1391.4×10⁴t. The geological reserves of oil-water layer are 123.5×10³t. In the west of the central region located in the middle of the Saertu anticline structure, there are five faults on the high top surface, all of which are normal faults to the northwest direction. There are 4 large faults, among which the fault 108# has an extension length of 1150m and a maximum fault displacement of 37.5m, while the extension length of 112# is 1440m and its maximum fault displacement is 127m. The fault 121# has an extension length of 1870m and a maximum fault displacement of 28m, and the extension length of the fault 126#t is 1950m and its maximum fault displacement is 93m[1].

2. Analysis on the problems and potential of the experimental zone
2.1. The oil layer has a low water absorption ratio a large difference between the layers
In the long-term development of oilfields, the contradictions and differences between layers and oil layers of different thicknesses are getting larger and larger. The greater the thickness, the higher the degree of utilization of the oil layer, and vice versa[2].
2.2. The difference in the pressure plane of the oil layer is large, and the proportion of the low pressure well is high

The current formation pressure of the Gaotaizi block in the west of central region is 9.67 MPa, while the total pressure difference is -1.89 MPa, and the formation pressure level is low. It can be seen from the plane pressure distribution that the pressure distribution is not balanced, and the proportion of low-pressure wells is high. The wells with a total pressure difference of less than -1.0 MPa accounted for 73.21%.

2.3. There are more low-efficiency wells, resulting in uncoordinated injection and production

In terms of inefficient wells, from the statistics of December 2015, there were 153 low-efficiency wells, accounting for 32.55% of the total number of wells. The oil layers of these inefficient well have poor developmental conditions and severe ineffective cycles.

2.4. The block water content of the block rises rapidly and the natural decline rate increases

In December 2015, the Gaotaizi block in the west of central region had a comprehensive water content of 96.02%, and the annual natural decline was 15.37%. Compared with December 2014, the annual water content increased by 1.02 percent, and the water content increased rapidly and the natural decline rate increased. The Gaotaizi oil layer in the west of central region had a total of 89 wells with water content greater than or equal to 98% in November 2015, including 19 in the sixth mine and 65 in the third mine. The high water-bearing wells cover most of the third mine.

2.5. The experimental zone is affected by the casing-damage well, with many broken wells for production

A total of 191 casing-damage wells were discovered in the Gaotaizi block in the west of the central region, including 114 oil production wells and 77 water injection wells. From the point of the casing damage, the majority is standard layer and accounts for 41.36% of the accumulated casing damage wells. The casing damage is mainly caused by fault and deformation, accounting for 36.65% and 47.12% of the number of casing damage wells, respectively.

2.6. The ratio of injection-production wells in the old well pattern is low

Since the encryption in 2010, the water-driven development well pattern of the block has been adjusted to the five-spot area well pattern. However, the high III layer system still uses inverted nine-spot area well pattern to mine, which makes the block subjected to the high ratio of oil-water wells. The contradiction between injection and production is increasingly prominent, and the utilization degree of the oil layer is also difficult to improve.

2.7. Problems in water injection process and testing

First, after the water injection well is further subdivided, the test workload increases, and the measurement and adjustment capability is insufficient. Second, the number of subdivision segment increases, and the packer was difficult to unblock.

3. Specific practices for controlling water and tapping potential

3.1. Research on fine oil layer description

Deepen the research on fine geology and do a good job in four aspects of scientific research.

- Increase the research and application of well-seismic reservoir description and find the remaining oil potential on the basis of new understanding of geological features
- Intensify the study of fine description of tectonic faults, and combine dynamic and static to find the remaining oil
- Increase the research on the identification technology of high-seepage channels and increase the application of multi-disciplinary tracer flow simulation technology
• Intensify the study of the microscopic pore structure and the remaining oil description

3.2. Fine injection-production structural adjustment

Carry out fine layered water injection work above the injection well. Increase the fine adjustment of the well itself, detail and quantify the Gaotaizi well stratification standards in small well spacing area, and improve the water driving degree of the block; Combine with shallow profile adjustment to perform the injection cycle optimization and effect analysis of inter-well and inter-layer cycles effectively, effectively control inefficient and ineffective water injection, and mitigate the contradiction of planes and interlayers; Improve the precision of high-efficiency intelligent measurement, and ensure wells injected and filled with water[5].

In the production wells, increase the application of the research results of fine description in dynamic analysis and adjustment, deeply tap arrow river channels and faults to cover the remaining oil by means of sealing holes, fracturing, etc.; Strengthen the low-efficiency and ineffective water plugging strength in circulation to control the overall water content rising rate of the block; Take the underground knowledge as the foundation to deal with the inefficient wells, and give full play to single well productivity; Govern long-time shut-in wells, increase water injection and oil production wells, and improve the relationship between injection-production well groups.

3.3. Apply water control and tapping potential technology of narrow river channels, to maximize oil recovery

3.3.1. Fine reservoir description further accurately characterizes and identifies the sand bodies of narrow river channels. The deepening of reservoir research has made certain changes in the distribution, orientation and scale of sand bodies, providing a reliable geological basis for water control and potential tapping.

3.3.2. Fully apply the reservoir description results to achieve efficient water control and potential tapping. The water control measures for sand bodies of the narrow river channels with high degree of flooding controlled by the well pattern are implemented, and the potential tapping of the narrow river channel sand bodies and the variation part that cannot be controlled by the well pattern is implemented.

In the water control, multi-direction high water content: The water-injection wells are subdivided into single point stop and control injections, controlling the super water-absorbent layer; single-direction high water content: water plugging is implemented in oil production wells, and high production and high water-bearing layer are controlled. According to the results of multidisciplinary research, the water shutoff of oil wells is implemented to change the direction of fluid flow and alleviate the plane contradiction.

In the potential tapping, the isolated river sand, the top of the thick oil layer and the degraded part of the river channel margin are the main targets for tapping potential.

The hole sealing in the imperfect injection-production well area is implemented to improve the relationship between injection and production of single sand body; Fracturing is carried out in the improved injection-production well area to increase the potential tapping of remaining oil[6].

3.4. Reinforce the intelligent research and realize the development and adjustment of quantitative management

• Improve the application of multidisciplinary digital model in the development and adjustment, and improve the accuracy of measures

• Quantify the standard limits of various adjustment measures, increase the application of GPTplan software, and realize the intelligentization by conventional measures
3.5. The adjustment technology of water control and efficiency improvement and deep tapping potential in small well spacing area of water-driven Gaotaizi in Sazhong is formed.

The Gaotaizi oil layer in the west of the central region adopts the five-point area well pattern of 106m, and it enters the ultimate mining stage of well pattern. In the past three years of the development and adjustment, it has a preliminary understanding of its mining characteristics, with mainly five characteristics, and targeted adjustments were made to these five characteristics.

- The well spacing is small and the water injection speed is fast. The water velocity is accelerated near the well spacing, and the tracer results show that the average time of exposure to agents is 45 days, and the agent exposes in the mainstream line after 13 days, with a fast breakthrough speed.

- The requirement for the length of the well section and the starting pressure are high. The average well section span of the block is 138 meters, which makes a big difference in the pressure requirements between the oil layers. The development of such a long well section leads to an unbalanced utilization of the oil layer, and a combination of periodic water injection to enhance pressure and measures reform to increase injection is taken to improve the utilization situation.

- The contradiction between perforation width and the longitudinal direction is prominent. The three types of oil layer mining objects are inside surface and outside surface reservoirs of less than 0.5m. However, in the wells that are actually mined, some thicker lump sand and oil layers larger than 1m are also mined at the same time, resulting in prominent inter-layer conflicts and unbalanced utilization of oil layer. The use of layer reorganization, strict control of high-permeability thick oil layers, pressure-raising to enhance the water injection strength of low-permeability and thin oil layers, improve the use of the situation.

- The contradiction in much utilization on the plane are increased. In the three-encryption area, the original well pattern used 439 wells, accounting for 19.7%. Although some thick oil layers are blocked during the utilization process, the thickness ratio of mining thickness greater than 1 m is still large compared to the triple-encrypted new well. For the well group of the old well utilized, the tracking adjustment is adopted, and stop and open actions are combined in a timely manner to adjust in stages. At the initial stage of encryption and production, the old wells use the well to reduce the amount of water injection and adopts plugging and stopping measures to strictly control the high-permeability oil layer, giving full play to the potential of the three types of oil layers. In the process of tracking adjustment, with the mining situation gradually allowing the stopping injection section, the pressure is increased and water is injected, perfecting the injection-production relationship of single sand body and improving the degree of utilization.

- Mining is carried out under the development condition of low pressure and high water content, and a large-scale pressure-rising water injection is adopted, adjusting by the combination of fine layers stopping, controlling and releasing.

3.6. Arrangement for water extraction measures of oil-water wells

There are three main approaches to the comprehensive and in-depth application of the well-seismic reservoir research results.

3.6.1. Adjust and improve the relationship of injection-production between well groups through injection-production system. For the layer GIII system, the inverted nine-spot area well pattern was transferred to the inverted five-spot area well pattern through conversion of the water injection well, and 17 wells require converted injection [7].

3.6.2. Improve the well block to develop well pattern through the corresponding holes sealing and plugging of oil-water wells. For the 25 oil-water wells after the poly-spectral experiment, there are 9 water injection wells, 6 wells needed to be sealed after plugging, and 16 production wells combined with the production of surrounding production wells to seal holes and plug, improving the block development well pattern.
3.6.3. Improve the utilization degree of the thin layer by fracturing. According to the requirements of the daily fluid production of the fractured well and the water content below the block average, the formation pressure higher than the block average, and the great contradiction between layers and planes, it is mainly concentrated on oil layers with poor sandstone development, which further improves the utilization of oil layers[8].

4. Conclusion and cognition

• The well-seismic combination research method was applied, and the establishment of a fine three-dimensional tectonic geological model was the basis for the foundation of fine potential tapping with high water content in small well spacing.

• Through deepening the detailed description of oil layers, the adjustment of fine injection-production relationship in the block was increased, and the fine injection-production structure was adjusted. The informatization, intelligent analysis and management proportion in the development and adjustment process were strengthened to achieve dual control objectives, summarizing and forming a set of technical mode for water-driven development supporting adjustment in a special high water-bearing period, which can effectively improve the level of water driving development and achieve the goal of “control water content, control it not to decrease progressively”.

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