Exploration and application of small well spacing development management mode in oilfield

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Abstract--The oil field enters the stage of ultra-high water cut development, especially after the third infilling, the well spacing is small. The water injection advances quickly, the water cut rises quickly, the control of natural decline becomes more and more difficult. According to the traditional oil field development management method, the oil field steady production difficulty will increase continuously. Therefore, we must constantly explore new methods of oilfield development to improve the quality and benefit of oilfield development.

1. Basic Facts
An oil mine is located in the west of Sazhong Oilfield, with a management area of 27.855 square kilometers and 3,441 oil and water wells, including 1,889 oil wells and 1,552 water injection wells. In 2011, it entered the stage of dense well pattern and small well spacing, the proportion of small well spacing accounted for 71.3% of water drive, and the Geological Reserve was 10174.52104T.

Well spacing and well sedimentary facies type is mainly Delta Front subfacies. Sand body type is mainly subaqueous distributary channel Sand and Delta front sheet sand. The well pattern density increased from 27.6/KM³ to 90.7/KM³. The surface construction is complex, the well pattern is irregular in local area, and the proportion of inclined wells is 49.83%. The interval of perforating well is large, the longest is more than 200 meters. And the permeability difference between layers is large. Which makes the pressure demand of each oil layer have great difference, the vertical contradiction is prominent. The interlayer production is uneven, because the well distance is close, and the injection-production speed is fast, the water well outburst is obvious, the qualified rate of two-month inspection is only 50%. Which leads to the rapid increase of water cut. In 2013, the water cut increased by 1.83 percentage points, and the natural decrease reached 22.8%. 10174.52104T.

The increasingly severe development situation requires us to constantly explore new ideas, new methods and new technologies for Oilfield Development Adjustment in order to establish a management mode suitable for small well spacing development adjustment. To this end, a mine closely around the goal of sustained and stable production of crude oil, to oilfield development as the center. low-cost water flooding as the focus of stable production, organization system management, technical personnel and operating backbone, joint discussion, in-depth analysis, research and development of solutions. Through continuous exploration and practice, the "Cross" development management method with small well spacing and dense well pattern has been gradually formed, and the development effect has been effectively improved.
2. Main connotation and practice of "Cross working method" in oilfield development

2.1. The main connotation of the development of "Cross working method"
"Cross work method" is specific to the oilfield development work. "Cross" is true and the data is true and accurate; precise analysis is fine carving; optimization, program adjustment; sub-level, sub-level water injection. Testing integrity test management is raise, improve water injection quality; control, control of ineffective injection and production; prevention, Comprehensive Prevention of casing damage; treatment, treatment of two low-well areas digital oilfield development. All the work around the development service development, actively explore the law of small well spacing development. Management of small well spacing development contradiction, and strive to improve the situation of small well spacing development, improve development efficiency.

2.2. Main practice of "cross working method" in small well spacing development
Guided by the spirit of the 19th National Congress of the CPC, with the purpose of consolidating the foundation for Oilfield Development. Maintaining stable production of crude oil, taking improving the development situation as the core, adhering to the principles of rational injection and production. Steadily increasing pressure and high-efficiency development, and through the development of the cross working method. The development situation of the small well spacing is improved obviously. The production is gradually stable and good, and the development level of the oilfield is further improved.

2.2.1. The information is true and accurate, and data acquisition is the foundation of development adjustment.
The foundation is shaky, and in order to deal with the problems of rapid advance of water injection from small wells, rapid change of pressure, and large fluctuation of production and water cut, "three guarantees, three checks, three times in time" for data acquisition. "Three guarantees" for technical cadres to contract high-yield wells, for production team cadres to contract metering rooms, and for geological groups to contract single wells. "Three checks" for technicians to carry out spot checks on a daily basis. And for technical teams to carry out monthly inspections, mine Coordination Quarterly Inspection; "three in time" that timely detection of problems timely processing. Adopt the method of trace management, responsibility to person, problem accountability adhere to weekly Operation Standard Study. Monthly development and Management Seminar, quarterly technical examination, and enhance the staff's standardized operation consciousness and ability, to put an end to the phenomenon of non-standard data. Inaccurate data and non-implementation of the system, to create a data management atmosphere in which everyone attaches importance to the accuracy of data. Everyone takes the accuracy of data, and to summarize a series of data management methods such as password samples and inspection cards to be popularized in factories. The data accuracy rate rose from 95% to more than 98%, six consecutive years in the forefront of the factory, for the development of adjustment laid a solid foundation.

2.2.2. In the face of the complicated contradiction between small well spacing and development, the dynamic blocks are not equal and reliable, so the problem of underground contradiction is actively analyzed, and the main contradiction and its main aspects are investigated one by one.
In the analysis of blocks and well groups, "three parts, three clear, one control" should be achieved. "Three parts," that is, the analysis of well patterns, well groups and sections. "Three clear," that is, the static data is clear, the dynamic changes are clear, and the potential of measures is clear. "One control" means firmly controlling the development situation. Depending on the static data and dynamic data, the structural cognition extends from oil-bearing formation to sedimentary unit. The reservoir cognition extends from plane distribution to three-dimensional space, the remaining oil cognition extends from qualitative to quantitative, and the block-by-block analysis is made. Based on the comprehensive analysis of the interference between the old and the new wells combined with the streamline relationship and the well location relationship. More than 3750 sheets of maps such as all kinds of facies maps, raster
maps and sand body connected maps are drawn, and the connecting conditions of small beds and single sand body injection-production relationship are sorted out one by one. Comprehensive treatment measures such as fracturing, subdivision, plugging, profile control and cyclic water injection have been adopted for 364 wells to control water cut and decline, which points out the direction for development and adjustment.

2.2.3. The optimization scheme is adjusted to meet the problems of multi-injection zones in new and old wells, prominent three contradictions, remaining oil dispersion, and uneven production of each layer, dynamic personnel in the program to create new thinking, put forward new ideas, explore new methods, seek new breakthroughs.

Four-combination, three-communication and two-control. "Four-combination", that is, the combination of injection-production relationship, injection-production Structure Adjustment, water cut changes, and formation pressure adjustment. "Three Communication" is to communicate with the team data changes, to communicate with the content of the geological program, to communicate with the test method; "two control" is to control water cut, control decline. Through continuous exploration, the program design has realized the transformation from adjustment of reservoir group to adjustment of single sand body, from understanding of layer mode and remaining oil to numerical simulation of remaining oil, and from increasing oil by measures to managing low-efficiency wells, to achieve one well one method, one layer one policy. Innovative implementation of hole filling + injection, subdivision + plugging, subdivision + SAPU round injection, plane oil and water well adjustment, cyclic rotation water injection, pumping thin well pattern water injection and other adjustment programs. Fine adjustment at both ends of injection and production, combination of lifting and controlling, 2204 wells were precisely adjusted, 180 wells were produced, 1943 wells were optimized, and the annual water cut rising rate decreased from 1.83% to 0.23%. We will promote a steady improvement in the overall development situation. Direction.

2.2.4. In order to solve the problems such as thick interval division and big inter-layer contradiction in the early stage of small well distance production, we increase the subdivision adjustment and make "three analyses, one persistence and one slowing down", three analysis namely: Analysis Well Group situation, technological conditions, string situation, adhere to a standard, namely "7788" subdivision standard, to achieve a slow, that is, slow down the rate of water cut rise.

A total of 608 wells were subdivided, and the average water injection interval increased from 3.86 to 5.5, of which 543 wells were above 5, and the average water injection interval reached 5.8. At the same time, the application of constant flow nozzle was increased, and a total of 209 wells with 328 layers were put into constant flow nozzle. The water absorption of high permeability layer was effectively controlled, the contradiction between interlayer and in-layer was alleviated, and the proportion of sandstone production increased by 46.35% from 32.27%. To be an effective means of development and adjustment.

2.2.5. As for the test management of trustworthiness, facing the problems of quick change of water injection from small well distance

Low rate of check and match, heavy workload of survey and adjustment, and difficulty of water cut control. We have achieved "three trustworthiness, three in time and one deepening" in test. "three sincerity" is the integrity of data acquisition, integrity site tracking, integrity testing adjustment. "Three timeliness" is the timely processing of problems, timely reporting of information, timely testing and allocation, "one improvement" to improve reservoir production. We innovatively carry out "six determination" test management, namely: "determination block length, determination contract area, determination test team, determination test team length, determination well layer quantity, determination water cut index". Each development block is divided into a number of areas, the test team contract fixed areas. Strengthen the combination of test team and dynamic block, improve the quality of the program. At the same time, the management and examination method has been improved. While examining the
test workload, the change of water content in the contracted area is not only an evaluation index for the dynamic block scheme, but also an evaluation index for the test team's test quality, improve the staff's sense of responsibility, mobilize the enthusiasm of the work. We also explore the implementation of a round-robin testing method to find a reasonable testing cycle, to achieve on-demand testing and adjustment, more accurate program adjustment, more reasonable testing and adjustment cycle, test quality and test efficiency has been improved. The monthly test capacity of each test shift was increased from 7.9 wells to 9.5 wells, the qualified rate of inspection and match was increased from 70.3% to 85.2%, and the qualified rate of test was increased from 92% to 97.3%. The factory convenes the "six fixed" test management spot meeting, promotes my mine practice. Is a powerful tool for development and adjustment.

2.2.6. To improve the quality of water injection, to meet the problems of low qualified rate of water injection and low compliance rate of water injection scheme,

Three optimization, three tracking and one improvement is realized. "Three optimization" is to optimize the test cycle, optimize the well-washing method and optimize the scheme design "three-track" means to track the operation. The progress of rectification and the change of well group, and "one increase" means to increase the qualified rate of separate layer water injection. Starting from four aspects of formation, well washing, well testing and operation, the whole process management of nodes is promoted, the individualized well washing of one well and one method is implemented. The individualized well testing of one well and one cycle is carried out, and the normal cycle of well washing and testing of problem wells is shortened by 60%, optimizing the design of water injection scheme, combining the increase injection with the adjustment of the scheme, the coincidence rate of the scheme is over 95%, and the precise water injection is realized. Optimizing operation flow, shortening all kinds of operation time, reducing the remixing rate from 7.3% to 3%. Shortening operation time from 30 days to 14 days, through various management and control, raising the qualified rate of separate layer water injection from 75% to over 87.1%, the realization of water injection and effective water injection provides a strong support for development and adjustment.

2.2.7. Controlling the ineffective injection and production, facing more than 98% water-cut wells reaching 32.68% of the well spacing,

The inefficient circulation is serious, and achieving "three thrusts, three adjustments and one reduction" in controlling the ineffective injection and production effectively. "Three-advance" means to advance cyclic water injection, drainage well pattern and intelligent test and adjustment. "Three-adjustment" means to adjust plane, interlayer and interlaye. "One-decrease" means to reduce invalid circulation. One is to control ineffective injection and production, apply water control technology in super high water cut stage to over 98% of ultra high water cut well groups. Carry out a total of 128 cyclic water injection wells at injection end, 96 well-times profile control, 702 well-times lower injection and 702 well-times high shut-in and 134 well-times interval pumping at production end. Water shutoff 111 wells, the average annual control of ineffective water injection 410,000 square, ineffective production 530,000 tons. The second is to reduce the low-efficiency injection-production, fine analysis of big well group with water-cut difference, fine adjustment, "raise and control" combination, optimization of liquid-producing structure, implementation of injection end subdivision. Layer adjustment 319 well times, plane adjustment 1389 well times, average annual control of low-efficiency water injection 890,000 square meters, the production end carries out the plane adjustment 1943 well times, the average year controls the low efficiency production 570000 tons. Promoted the development efficiency promotion.

2.2.8. In order to prevent casing damage comprehensively, facing the problem of increasing casing problem wells and increasing pressure difference in an old casing damage area after infilling.

We have achieved "three prevention, three control and four treatment" in casing damage prevention and control, "four prevention", that is, prevention from system and prevention from management. "Three controls" are control standard layer, control dangerous layer and control abnormal well. "Four controls"
are workover control, high casing killing well control, low efficiency well control and high pressure area control. According to the change of pressure and the implementation scheme of casing damage zone, 382 wells were adjusted downward, 142 wells were adjusted downward by overlying rock pressure, 406 wells were controlled and investigated, 305 wells were repaired, the diameter of casing damage well was decreased from 106 mm to 110 mm, and the repair rate was increased from 93.85 to 95%. There is no standard casing damage, and the extent of casing damage has been reduced. The orderly operation of the development adjustment is ensured.

2.2.9. To control the two low well areas, facing the problem that the formation pressure is only 8.74 MPa
The lowest submergence degree is only 167 meters, and the proportion of the low submergence degree wells below 200 meters is up to 25.5%. We have achieved "three sets, two lifts and one guarantee" in the treatment of the two low wells. "Sanding" means the level of production, the degree of perfection and the technology of measures. "erding" means the increase of injection-production ratio of well group, the increase of producing degree of thin and poor layer, and "one guarantee" means the guarantee of well group development effect. According to the actual situation of the well group, the sub-block sets up the adjustment limit, increases the water raising intensity to the two low wells. Altogether increases the water volume 879 times, the water injection pressure increases 1.42 MPA, the daily water injection volume increases 17484 square meters, increases the water injection 8.69 million square meters cumulatively. The pressure between the well and the formation is recovered from 9.13 MPA to 9.52 MPA, the submergence is increased from 167 m to 339 m, the well below 200 m is reduced from 25.5% to 18%, and the underground liquid supply capacity is fully recovered. It provides a strong impetus to improve the development situation.

2.2.10. In the development of Digital Oilfield, facing the problems such as numerous data after the well is put into production
Large amount of follow-up and adjustment work, and changeable situation of underground water injection, according to the actual production situation, computer technology is used to achieve "two depending on four advancing one improving". Two support: That is, rely on digital acquisition system, oilfield development and management platform, to promote the four-dimensional construction: digital data acquisition, class form automation, development and analysis of intelligent, paperless conference office. 1. Improve: Increase your productivity. In the technical system to promote the application of GPTMAP, Gpiplan, TDATA and other intelligent software to improve the efficiency and accuracy of development adjustment. In Gaotaizi block in the west of central district, 54 intelligent measurement and adjustment experiments are carried out to realize the visualization of pressure and water in each layer. Adjust the water injection in every layer at any time, analyze the law of pressure and water in each layer, and ensure the qualified rate of water injection. The mine compiles 82 programs by itself, forms the Development Management Platform, realizes the development data automatic arrangement and export. The development target automatic computation, the Data Management Operation Trace visualization, the test data password operation, enhances the work efficiency above 50%, for precision development adjustment escort.

3. Implementation effect of "Cross working method" in oilfield development
The integrated management of "Cross working method" in oilfield development has achieved remarkable results, and the development indicators have shown a good development trend.

3.1. Complete the oil and gas task, tamp the stable production base in 2018
Small well spacing area production overcome decline, Arrow up, from 1,522 tons to 1,612 tons, I mine water drive not measures to produce crude oil 575,300 tons, 1,300 tons over the plan, 100.23% completed the plan, aT $70 per barrel, 44.59 million yuan was realized, consolidating the basis for stable production.
3.2. The water cut remains stable, showing the value of water cut rising in water flooding at the development level.
It has been carefully adjusted through the cross work method and has decreased from 1.44% in 2013 to 0.23% at present. The increase in water cut has been fundamentally contained and good development benefits have been achieved.

3.3. The degree of production is improved and the development situation is stable and good.
Through the cross working method, the formation pressure is restored to 0.39 MPA. The submergence degree is restored to 143 meters, the injection-production rate is controlled by 4.8 and 3.1 percentage points respectively, and the ratio of sandstone production is increased by 7.1 percentage points. The development of small well spacing has entered a virtuous circle, and the development situation is steadily improving, which has promoted the steady growth of economic benefits. Though the cross working method has been improved and developed for six years. There are still many deficiencies in this management mode. It will be developed and improved continuously in the next step, which will provide more powerful impetus for the development of oil fields.

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