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Follow-up water drive inefficient and ineffective cycle comprehensive management countermeasures

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Abstract: When an oilfield is developed with a polymer drive, the injected polymer will play a role in improving the already formed dominant channel between oil and water wells, but after the polymer drive block is transferred to the subsequent water drive development, an inefficient circulation field of injected water will be formed between oil and water wells again. This paper mainly applies dynamic and static data, combined with dynamic analysis and adjustment and optimization software of high water-bearing oilfield, to identifying the dominant channel of subsequent water drive, actively take comprehensive management countermeasures, reasonably control the injection and recovery rate, control inefficient and ineffective injection and recovery, so as to improve the effect of subsequent water drive development.

Key words: advantageous access; injection and extraction rate; integrated tapping.

1. Introduction

Block A is divided into Block A and Block B, with an oil-bearing area of 13.68×km^2, geological reserves of 1,793.79×10^{4}t, pore volume of 3,203.54×10^{4}m^3, and a total of 756 injection and recovery wells, of which 356 are injection wells and 399 are recovery wells. In November 2014, Block A and Block B stopped injection and entered the follow-up water drive phase, with a polymer drive recovery of 9.81%. The water content in the follow-up water drive stage is rising rapidly, the remaining oil distribution is fragmented and complex, the comprehensive water content reaches 98.82%, the proportion of wells with water content above 99% is more than 60%, and the inefficient and ineffective circulation is serious. Therefore, to carry out the identification of inefficient and ineffective circulation in the follow-up water drive and implement comprehensive management countermeasures is necessary to improve the development effect of the follow-up water drive block.

2. Subsequent water drive advantageous channel identification method

2.1 Dynamic and static data identification advantageous channel

2.1.1 Planar differences create superior access

Planar contradictions lead to differences in repulsion and are influenced by planar inhomogeneity， which create inefficient and ineffective circulation in the direction of well-developed oil reservoirs and high permeability.

For example, the low bend narrow river channel single injection and single mining type—— due to the narrow width of the sand body in the low bend river channel, this leads to a sudden advancement within the well group along the course of the river channel, creating an inefficient and ineffective cycle. 5 of these well groups were identified.

For example, inefficient and ineffective circulation is formed in the direction of well-developed reservoirs and high permeability due to planar inhomogeneity， and eight such well groups were identified.

2.1.2 Differences between layers create a dominant channel

Due to the large differences in permeability and development thickness of each layer and the influence of inter-layer conflicts, injection water tends to burst along the high permeability layers, and 27 well groups of such inefficient and ineffective circulation are identified.
Example.

2.1.3 Intra-layer differences create dominant channels

Water injection burst type at the bottom of thick oil layer——inefficient and ineffective circulation exists in the lower part of the thick oil formation due to the positive rhythm of the reservoir and gravity, and 21 well sets of this type were identified.
Example

2.2 Dynamic production data changes to identify dominant channels

By comparing the change in injection pressure in the three stages of pre-injection, post-injection and subsequent water drive, the degree of decline in injection pressure from production development to the subsequent water drive stage is judged; the greater the decline, the greater the likelihood of inefficient cycles forming in the subsequent water drive stage [2].
$D=(P_1-P_0)/(P_1-P_2)$ where: P_0 is the pre-injection pressure, P_1 is the post-injection pressure and P_2 is the subsequent water drive pressure

2.3 Combining with SimSim software modelling to identify dominant channels

SimSim software modelling combines a number of data such as geological data, shot hole data, geological reserves, reservoir parameters, water absorption in the formation section and historical measures and so on to analyse the remaining oil more accurately.
The SimSim software was used to create a flow pipe diagram of the subsequent water drive block, and by comparing the colour and width of the flow pipe lines, the intensity of water absorption in each direction , the inefficient and ineffective cycle was judged.
Combined with the flow pipe diagram to determine the dominant channel of the well group, design the next step of the single well measures for the dynamic production of the single well, and predict the effect of the measures, it can provide a reliable reference for the development of practical measures.

3. Follow-up water drive inefficient ineffective cycle comprehensive management countermeasures

The subsequent inefficient cycle of water-driven ineffectiveness is influenced by a number of factors, of which development indicators such as injection rate and injection ratio are important factors affecting the profile and water content changes [3].
The poly-drive block enters the subsequent water drive stage, influenced by the plane, intra- and inter-formation contradictions. If the high injection rate is maintained, the implementation of the high permeability layer absorption ratio is prone to the formation of inefficient and ineffective circulation strips. By comparing the development index of the subsequent water drive in Xingbei, the injection rate in the subsequent water drive stage is maintained between 0.06~0.08PV/a and the fluid recovery rate is maintained between 0.07~0.10PV/a. The development effect is good.
At the beginning of the transition of the polymerization drive to the subsequent water drive phase, the injection pressure will drop significantly, and in order to improve the mobilization of the low permeability layer, the injection pressure will often be increased by increasing the injection intensity, which will lead to an imbalance of injection and recovery. Through comparative analysis, the subsequent water drive injection to production ratio is maintained between 1.1 and 1.3, and the development effect is better.
Combined with the subsequent water drive stage reasonable injection and extraction rate, injection and extraction ratio, block A and block B take "transfer, stop, expand, replace" and other measures to control inefficient and ineffective cycle.

3.1 Increase efforts to stop plugging inefficient well formations

Entering the subsequent water-driven stage, influenced by the longitudinal inhomogeneity, inter-layer interference is more serious. For this reason, we should increase the efforts to stop plugging the high permeability layer and control the injection and extraction of inefficient and ineffective layer sections.

The production situation of 406 oil and water wells in Block A and Block B was analyzed well by well. And combined with 174 test data, one was to select 2 areas with high water content levels to take centralized layer stoppage, implementing centralised stoppage of 14 wells in the Portuguese I2 layer and 18 wells in the Portuguese I3 layer; 76 injection wells with large pressure space, fast rising water content and large proportion of single layer activation were stopped for high seepage. After stopping the layer, the daily injection volume of injection wells dropped by 14m3, 53 extraction wells were affected, the average daily fluid production of a single well dropped by 9.2t and the water content dropped by 0.27 percentage points.

The 52 extraction wells with large differences in permeability, persistently high water content and high liquid production were plugged and adjusted to reduce ineffective output. After adjustment, the average daily liquid production per well decreased by 23.2t and water content decreased by 0.31 percentage points.

3.2 Implementation of pulse injection and extraction

Implement alternate injection intensity pulse injection and recovery of 42 wells, change the direction of repulsion and reduce the planar contradiction; the first cycle will shut down the central injection well connected to the recovery well, and implement a downgrading of the injection wells around the central injection well to increase the injection intensity of the central injection well and tap the remaining oil between wells; the second cycle will raise the volume of the injection wells downgraded in the first cycle, and at the same time reduce the injection intensity of the central well and change the direction of fluid flow to slow down the water-bearing rebound rate. The control of inefficient and ineffective daily water injection of 320m^3 and daily fluid production of 450t. 7 wells were affected and the monthly water content rise rate was slowed by 0.04 percentage points.

3.3 Pumping thin well points to extend well spacing

The cumulative oil production per unit thickness is relatively high, the water content level is high, the sink level is high in the remaining oil less well area to implement the pumping thinning well point to expand the well spacing 50 wells, water wells are switched on and off in two rows, at the same time, the open well water well row a well spacing oil wells off, the injection and extraction well spacing is expanded from 125m to 374m to improve the efficiency of water injection, the monthly water content rise of surrounding wells slowed by 0.07 percentage points.

3.4 Increase layer segment subdivision water injection efforts

The amount of water in the layer section of the poly-driven tubular column wells could not be adjusted, and the pass rate of check and match was only 33%, making it difficult to stop the layer, with a success rate of only 26.3%. For this reason, 126 injection wells with uneven water absorption in the layer section and relatively low water content in the well group were replaced with water-driven tubular columns, and the thick oil layer was subdivided by increasing the subdivided water injection adjustment [3], and the layer section with high water absorption was stopped and 86 layers were restricted by using test adjustment to control the inefficient cycle of the highly waterlogged section. After the test adjustment, the water absorption condition of the layer section was improved, the percentage of water absorption in the high permeability layer decreased by 6.4 percentage points, and the water content of 182 wells around the quarterly comparison decreased by 0.2 percentage points.

Through the above comprehensive tapping, the inefficient and ineffective water injection of 484,100 cubic metres and inefficient and ineffective fluid production of 371,500 tonnes were controlled in 2017, and the water content of Block A and Block B basically did not rise, slowing down the monthly water content rise by 0.21 percentage points compared with the fourth quarter of 2016.

4. Conclusion and Awareness

(1) The effect of subsequent water drive development is mainly influenced by geological conditions, injection rate and other factors.

(2) The method of identifying the dominant channel of subsequent water drive is more complex, and a comprehensive analysis of dynamic and static data should be carried out to make a comprehensive judgement.

(3) The injection rate should be appropriately controlled in the subsequent water drive phase, with the injection rate controlled at 0.18~0.20PV/a and the injection ratio preferably controlled at 1.2 or less.

(4) In well areas where the non-homogeneity of oil formation development is enhanced, methods such as pumping thin well points and periodic water injection can be used to control inefficient and ineffective circulation.

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