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The Numerical Simulation of Serious Flooded Area of Jin-45 Block

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Abstract

The serious flooded area of Jin-45 Block began trial mining in 1984, Expericing conventional dry pumping, steam stimulation test and large-scale steam stimulation[1-2]. After nearly 30 years' development with active edge and bottom water and sufficient energy, there is a high percentage of reserves and the plane and vertical plane encryption, can't be adjusted. The condition of edge and bottom water is serious, average recovery rate of water of producing wells is high, production decline amplitude increase, exposing a series of problems. Referring to the steam stimulation turn to steam drive experience of pilot test area, building geologic model with Petrel software, setting up edge and bottom water reasonably, making history matching and project estimate, analyzing characteristics of steam flooding of the flooded area. Providing theoretical guidance and basis of turning to steam flooding of serious flooded area[4-6].

Key words: Flooding; Steam flooding; Numerical simulation; Optimization

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INTRODUCTION

Jin-45 Block is the largest heavy crude oil in Liaohe Oilfield. The highest annual oil production was 123×10^4 t. The main block is Jin-91 block. The block put into production in 1984, it has experienced the throughput test, large-scale throughput development, well pattern adjustment and other development process. The degree of reserve recovery was 8.75% at the end of 1991. It was adjusted for two times of well pattern thickening in 1992 and 1999. The well spacing has been tighten from the original 67 m to the current 83 m. As of 1 June 2013, the reserve recovery degree of research work area's stream huff and puff has been up to 45%. The accumulation of oil/gas ratio was 0,614. Part of the well water in recovery rate is as high as 200%.

Influenced by edge-bottom water, it was corroded seriously. At present, it has come into later period of throughput development. Development effects are progressively worse. We should transform the development mode quickly. Use Peterel software to build phase controlled property fine geological model. CMG numerical model software was used to simulate the edge of bottom water and predict various flooding scheme, optimize injection-production parameters and layer series of development, for providing reference for oil reservoir with edge bottom water to steam huff and puff.

1. NUMERICAL MODELING ESTABLISHMENT AND HISTORY MATCHING

1.1 The Establishment of Fine Geological

The study area is typical active edge water and bottom water block of Liaohe oilfield, the sedimentary facies of group 1 belongs to the front fan delta's sedimentary facies deposition. And the mico facies of braided distributary channel in the north-south is given priority. The work area's river channel sand in braided river channel has accounted for 69.8% and in river channel is 27%. In braided distributary channel is only 3.2%, so the set up of geological mode simply according to the control of sedimentary facies to the sand body is relatively coarse. The study is controlled by lithology. It can distinguish the minimum thickness of 0.5 meters of sand body according to the modeling fine degree. We have established lithology mode of study area on the basis of sedimentary facies mode. Finally, the parameters of reservoir bed, likewise, porosity, permeability, oil saturation and net thickness ratio of 3D quantitative geological model. Planar mesh model and the small layer partition as shown in Figure 1, Figure 2.

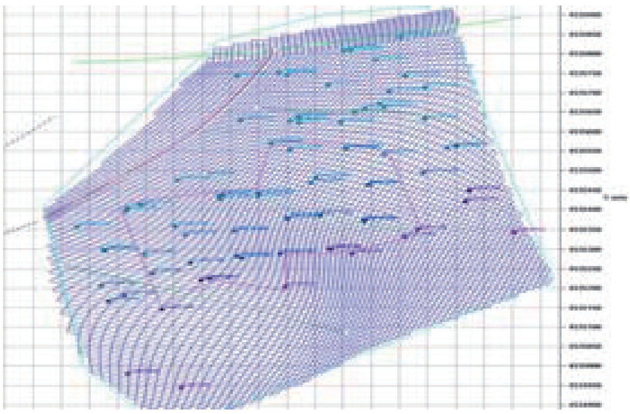

Figure 1
Planar Mesh Model

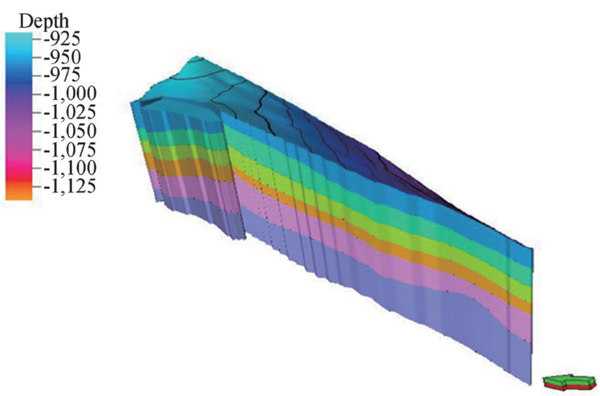

Figure 2
Model for Longitudinal Layer Division

1.2 The Numerical Model of History Match

The oil layer's physical property parameters used in the simulation, may not accurately reflect the true situation of reservoir. Therefore, the differences between the simulation result and the actually observed reservoir dynamic calculation have been still existed, sometimes they differ greatly. In order to reduce the differences, the dynamic prediction should as close as possible to the actual situation. Now, the history matching method is widely used in the whole process of actual simulation in the reservoir. The compression coefficient, rock permeability, relative permeability curve and other physical parameters should be properly adjusted.

The difficulty of history matching is the fitting of daily oil production process. It is also the most time-consuming. Because the geological condition of each well is different, the analysis of each well is necessary. By adjusting the relative permeability curve, completion factor and surrounding rock compressibility of borehole to realize the fitting of schedule production.

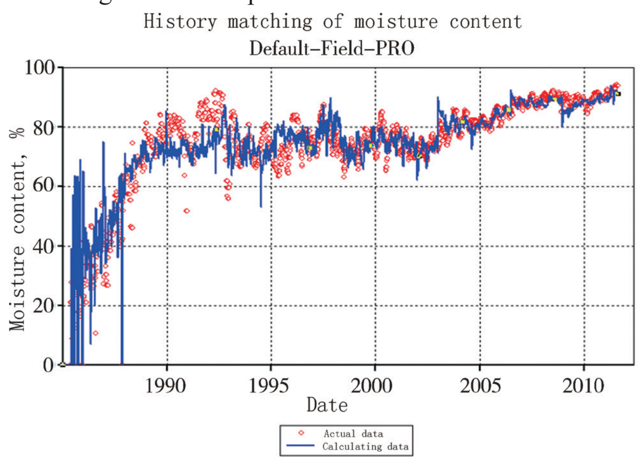

Figure 3
History Matching of Daily Oil Production

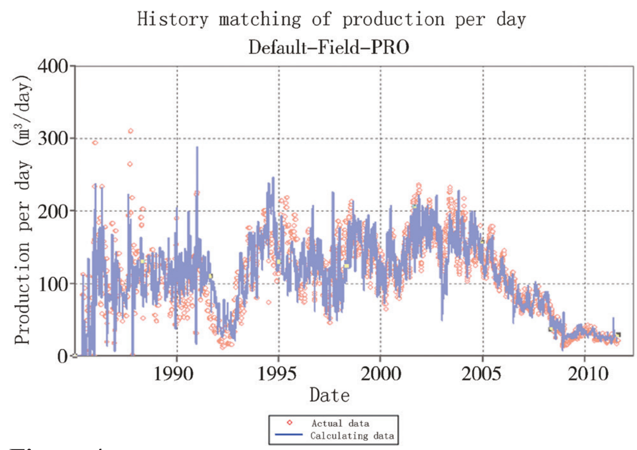

Figure 4
Moisture of History Matching

The stream huff and puff history matching has been carried out for 29 years, from August 1986 to June 2003, with the application of CMG software. Cumulative liquid production, daily output liquid, cumulative oil production, and daily output oil can reach the fitting standard. 80% production wells reached the fitting target of single well. Getting ready for the next step of budget. After the adjustment, model fitting average error was 2%, now the study area of oil production is 25.04 t/d .

2. THE ESTABLISHMENT OF WATER

2.1 Water Intrusion

The incursion of edge and bottom water make the late stage of cyclic steam stimulation effect become worse, it's the main problem of affecting the efficient development block. Effect of water invasion on development impact mainly displays in: a) The southern edge of water invasion and bottom water coning test area quickly, result in oil well is plugged frequently by water. It is difficult to product normally. b) Water invasion leads to short cycles of steam stimulation, oil/gas ratio and periodic oil production are low. c) Well water invasion affects the steam huff and puff of adjacent well.

2.2 Based on the Mathematical Model of Water

Water mainly refers to the edge (bottom) of water's position and the quality parameters (such as volume, water invasion index). In the mathematical model, the water body is defined by the boundary conditions. Its type and size impact directly on the whole unit's energy and dynamic of reservoir.

2.2.1 Analysis of Water

According to the geological understanding of the block, also specifies the general direction of edge water. By using the Fetchovich analysis method and Carter-Tracy analysis method to calculate the size of edge water's water body.

Fetchovich analysis method is based on stationary index and water pressure and the material balance between water pressure and cumulative inflow. For this type of water, from water to the reservoir is very similar to the flow from the reservoir to the well. Therefore, the water invasion of this type water body is similar to the productivity index of well. Through the CMG numerical simulation to set the speed of the water invasion, and the original oil-water interface to display the results of water body's size.

Carter-Tracy water analysis method is an approximate, completely instantaneous (unstable) water model. The type of water requires the user to provide a dimensionless time and dimensionless pressure data sheet of effecting functions.

2.2.2 Network Water

The analysis of water is simple and convenient, with the application of CMG simulation software. Water position and thickness are provided, we can simulate water. But the analysis of water has certain limitations. To calculate the heat transfer can not convergent, easily be wrong and have an effect on calculation, therefore, the establishment of grid water should be taken into consideration. As shown in Figure 5.

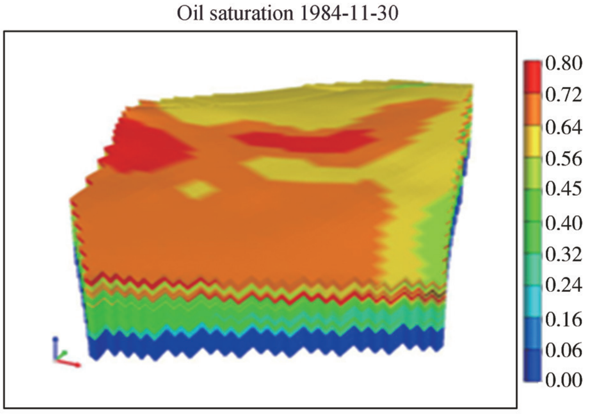

Figure 5
Bottom Water of Reservoir Water Set

Grid water is more accurate to be set, but its understanding of block water's requirement is relatively high. The establishment of grid water is equivalent to that the water is a portion of the formation. On the basis of the original geological modeling, to extending out of water, Test block bottom water is in this way.

3. STEAM FLOODING OPTIMIZATION DESIGN AND DEVELOPMENT PROGRAM

3.1 Well pattern optimization design

(a) At present, the 83 m square well spacing can be adjusted as three kinds of patterns (Figure 6-19), the contrast of three well networks are based on a complete well. To optimize the rate of gas injection, gas injection dryness fraction and production factor. The field operation conditions are taken into the consideration of parameter design.

(b) Each well is using the optimal injection-production parameters, comparing with the optimal results. The optimal scheme is the best economic benefit and the best recovery.

Comprehensive comparison, back to the small font spacing is the preferred plan. It has the advantages of high gas oil ratio, higher recovery rate and higher economic benefit.

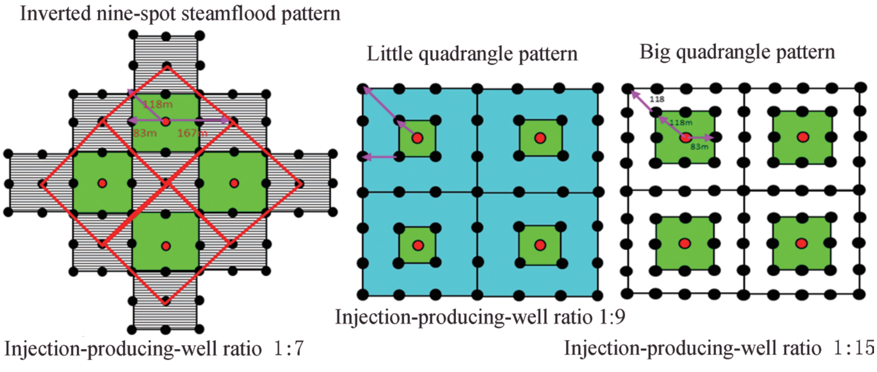

Figure 6
Schematic Diagram of Different Wells Network Solution

Table 1
Injection-Production Parameter Optimization

means Constant rate to inject gas (real time blocking)	Cumulative oil 10^4 t	Net oil production 10^4 t	Cumulative oil/ gas ratio decimal	Interval recovery degree%	The rate of oil production %	Single well group reserves 10^4t	Unit net oil reserves 10^4t
Anti-nine point	3.22	1.73	0.131	17.33	2.31	18.6	9.3
Back to the small font	6.99	3.41	0.12	15.45	2.1	45.2	7.54
Back to the big font	8.78	3.78	0.106	11.87	1.58	73.9	5.12

3.2 The Optimization Design of Stream Flooding Layers

According to the characteristics of water flooded zone: 5 & 6 zones have a large area of water. The development of steam flood will affect development effect. So the design and development of zone 4, zone 5, zone 6. By numerical simulation to predict target is the comparative study. Cumulative oil/gas ratio and million tons of net oil producing of four zones are the highest, economic benefits are the best, so to choose the development of four zones scheme.

Table 2
Optimization of Producing Position

Zone	Cumulation-production oil ×10^4 t	Cumulation-injection gas ×10^4 t	Cumulative oil/ gas ratio	Interval recovery degree %	Net oil reserve ×10^4 t	Million tons of net oil reserve ×10^4 t
Four	11.26	76.32	0.147	11.25	6.58	58.48
Five	14.26	12.58	0.113	14.25	6.56	45.98
Six	16.59	14	0.118	16.57	8	48.28

3.3 Optimizing Design of Injection-Production Parameter of Steam Flood

3.3.1 Gas Injection-Intensity

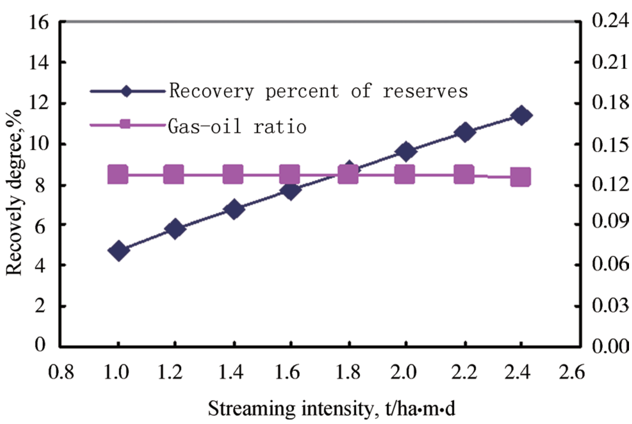

Figure 7
Bottom Water Reservoir Water Set

In order to make steam flood effectively, the way is to inject enough dryness of stream in reservoir by the high speed. For the strongly heterogeneous sill-like reservoir, the high injection rate will cause premature gas breakthrough (or fluid overflow), the thermal efficiency is decreased, if the injection rate is too low, will cause bad effect of stream flooding, numerical simulation are optimized for it.

Stream injection-intensities of simulation study are respectively: 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4 t/d·ha·m, injection-production ratio is 1.2 and dry stream is 55% of the stream flooding production effect.

3.3.2 Production Factor

From the stream flooding mechanism, in the stream flooding process, the reservoir pressure should drop as low as possible, stream flooding injection ratio should be greater than 1. But for oil reservoir with edge and bottom water, it's not right. Because the decline of invasion amount will increase the edge bottom water (or external fluid inflow). Analysis of the relationship between throughput stage water influx and injection-production ratio, if production factor ratio is close to 1, water influx is the lowest. In the stream flooding process, only when the injection-production ratio is greater than 1, it can achieve good stream flooding in the reservoir.

Simulation studies of the injection-production ratio respectively：0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5 injection-intensity is 1.8 (stream injection rate of single well is 282.204 t/d), stream ratio is 55%, so there are the stream flooding production effect.

The numerical simulation results showed that production-injection ratio is 1.2 in the test area can be best for stream flooding effect, daily oil production increased steadily. When the injection-production ratio is greater than 1.2, it will cause water influx seriously.

3.3.3 Stream Injection Dryness Fraction

In the lower injection speed, by properly increasing dry degree also can achieve the same heat injection speed that by injecting in high speed. Simulation study on the stream flooding production effect of the bottom stream dryness were: 20%, 30%, 40%, 50%, 60%, stream injection-intensity was 1.8 T/d·ha·m (gas injection of single well is 282.2 t/d), injection-production ratio is 1.2 (production fluid of single well is 52.1 m^3/d). The stream dryness fraction is stream flooding breakthrough more advance, water influx is lower, the final optimization of dryness fraction is 55%.

CONCLUSION

(a) Grid water can fine description of water properties, large amount of computation, higher requirement of the computer, analysis of water needs to repeat debugging, with the dimensionless parameters. This model uses two kinds of water binding mode.

(b) Back small well shaped mesh with respect to the inverted nine spot well pattern. Oil production ratio, cumulative oil stream ratio, stage of recovery and million tones of reserves net oil were high. So for the back small well shaped network to realize the optimization of injection-production parameters design and development horizon.

(c) Numerical model simulate various of gas injection-intensity, injection-production ratio and gas injection dryness. With millions of net oil and oil /gas ratio as the main reference object. Recommend injection scheme.

REFERENCES

[1] Yang, Y., Wang, H. H., & Kang, Y. L. (2007). The super heavy oil stream huff and puff wells dynamic characteristics and water monitoring analysis. *Journal of Chengdu University of Technology*, *34*(1), 73-75.

[2] Li, L. X., Wu, F., & Zhang, L. H. (2013). The fracture cave reservoir water breakthrough and water research experiment. *Journal of Southwest Petroleum University*: *Natural Science Edition*, *2013*, 1-8

[3] Yue, Z. Q. (2008). *Leng 41 block water invasion regularity and integrated control technology research and application*. Beijing: China University of Petroleum.

[4] Wang, C., Li, Y. P., & Zhang, P. Y. (2003). The extra heavy oil reservoir encryption throughput after converting to steam flooding feasibility and pilot test. *Henan Petroleum*, *17* (2), 36-38.

[5] Zhou, Y. J. (1995). By steam flooding in heavy oil reservoir with improvement effect of edge and bottom water. *Oil and Gas Recovery Technology*, *3*(3), 37-46.

[6] Yu, J. F. (2009). *Du 229 block geological study of ultra heavy oil reservoir*. Beijing: China University of Petroleum.