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The Application of Dual - system Thought in the Study of Reasonable Injection - Production Ratio

SONG WEN-BO
(The eighth production plant of Daqing oilfield co., LTD. Daqing, Heilongjian, China 163514)

Abstract: In order to achieve the goal of accurate water injection in the oilfield, it is necessary to clarify the reasonable injection / In this paper, the Dual - system thought is used to study the reasonable injection - production ratio. Through the numerical simulation of reservoirs and synthetical consideration of the water consumption ratio, reserve retention ratio, development effect and oil production speed of different types of oilfields, the range of injection - production ratio of four blocks in different water content stages.

Key words: dual - system ; reservoir numerical simulation; reasonable injection-production ratio

1 Introduction

1.1 The Thought of "Dual System" in the Study of Injection and Production Ratio

The study of injection and production ratio carried out by early scholars is mostly limited to the research based on the balance of the amount of injection and production. During the development process, the instantaneous injection - production ratio is changing, but the cumulative injection - production ratio is 1. This type of study hardly considered ineffective water injection, and is not suitable for low permeability fields with greater spillage.

Considering the spillover, this paper uses the reservoir numerical simulation method to study the injection and production ratio. In the numerical simulation study, the pressure relief layer and the relief well are set up to simulate the ineffective water injection in the model. In the process of the study, two systems were established, namely, the balance system and the research system. Injection and production wells and reservoir are the research system for simulation of non - balanced injection and production development of low permeability oilfield. Research system, pressure relief layer, pressure relief wells are the balance system to ensure the material balance of the entire system.

1.2 Application of "Dual System" in Reservoir Numerical Simulation

Using the "Dual system" method to carry out the numerical simulation of reservoirs mainly introduced the concept of "relief wells" and "pressure relief layer" in the reservoir numerical simulation model. In the model, a research layer and a pressure relief layer are established. In the research layer to set up production wells and injection wells perforation development while in the pressure relief layer to set up pressure relief layer to relieve pressure.

Research system, including simulation layer, simulated well W, simulated well O. Injection / Output Ratio IPR = $W_{Injection}$ / O_{Output}. Balancing system, including research system, pressure relief layer, relief well X.

Injection and production ratio simulation method: two simulation layers are used, one of which contains oil layer of the injection-production wells and the other is a pressure relief layer containing pressure relief wells to change the simulated oil reservoir injection-production value and simulate the development parameter with different injection-production ratio. Set fixed

injection strength of the production wells, and the injection wells inject water with different injection and production ratios from 1.0 to 2.0.

Table 1 Theoretical model reservoir and development parameter table

Block name	Sand type	Oil properties	Porosity (%)	Permeability (mD)	Oil saturation (%)	Geological reserves (10^4t)	Net thickness of the reservoir (m)	Output speed (m^3/d)
A	River sand	Oil	0.21	80	0.65	6.39	2	2
B	River sand	Oil- water	0.21	80	0.55	5.40	2	2
C	Seat sand	Oil	0.19	60	0.65	8.67	1	1
D	Seat sand	Oil- water	0.19	60	0.55	7.33	1	1

2 The Application of "Double System" in the Study of Reasonable Injection - Production Ratio

2.1 Simulate the water consumption of different types of blocks with water changes

If the reservoir is rigid water flooding, the whole system is always a balanced injection-production. The actual reservoir is flexible water flooding, and the whole system

gradually achieves a balanced injection-production. The difference between the two water injections of the pressure relief wells in the same water content stage is defined as water consumption. And the percentage of water consumption and production of oil wells is defined as water consumption rate.

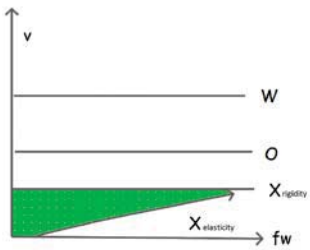

Fig.1 Schematic diagram of water consumption changes

If the reservoir is rigid, define X_{rigid}=W-O, fixed value. If the reservoir is elastic, the Definition of $X_{elastic}$=W-O, the value is gradually increased, variable value.Define water consumption = $X_{Rigidity}$-$X_{Elasticity}$, water consumption is gradually reduced.Define water consumption rate = water consumption / O × 100% = (W-O-$X_{elasticity}$) / O × 100%.

The water consumption rate increases with the increase of the injection-production ratio. There is water consumption in the reservoir block. At the beginning of the same layer, namely the

middle stage, there is water consumption. In the middle and high water stage, the proportion of water consumption decreases steadily with the increase of water injection-production ratio.

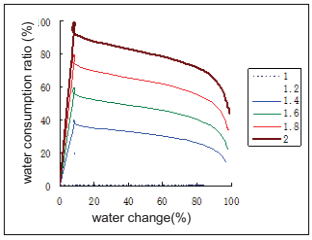

Fig.2 A block water consumption ratio with the water change curve

In the high water stage, the proportion of water consumption decreases sharply with the increase of injection-production ratio. In the same water consumption of different blocks, the injection-production ratio varies. AB blocks need a higher injection and production ratio than CD blocks in the same development stage of the same water consumption. The reservoir layer needs a higher injection-production ratio than the same layer with the same level of water consumption in the same development stage.

2.2 Simulation of different types of block reserves retention with water changes

As a result of the use of ultra-balanced water injection, part of the reserves are forced into the

elastic layer and form reserves which can not be used by water flooding, which are defined as

reserves retention. In the numerical simulation model of reservoir, the oil production rate of the pressure relief well is the reserve retention rate, and the cumulative output of the relief well is the total amount of reserve retention.

Define the reserve retention ratio = ΣXo / N × 100%, the reserve retention ratio increases with the increase of injection and production ratio.

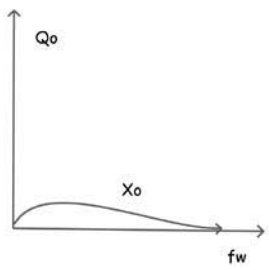

Fig.3 Reserves retention with water-containing curves

There is reserve retention in the entire process in the reservoir block. And reserve retention only exists in the middle stage in the same layer block. In the middle and high water cut stage, the proportion of reserve retention

increased sharply with the increase of injection

and production ratio. In the high water cut stage, the retention ratio of reserves gradually became

unified.

In different types of blocks under the same retention ratio, the injection and production ratio is different. In the same development stage of the same retention ratio, Song North needs higher injection and production ratio than Song South; In the same stage of development of the same retention ratio, the reservoir layer needs higher injection-production ratio than the same layer.

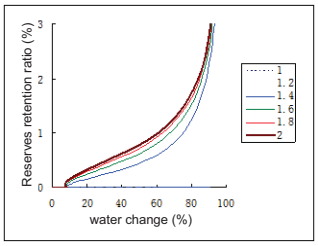

Fig.4 A block and C block reserves retention ratio with the water change curve

2.3 Simulation of different types of blocks under different injection and development ratio of the development effect

The higher the injection-production ratio, the worse the development effect, but the variation

gradually decreases. The lower the injection- production ratio, the lower the oil production rate, but the decreasing rate gradually decreases.

In different types of blocks with the same development effect, the injection and production ratio is different. In the same development stage with the same development effect, CD block requires a lower injection and production ratio than AB block; In the same development stage of the same development effect, the same layer requires a lower injection-production ratio than the oil layer.

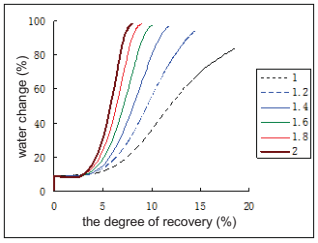

Fig.5 A block of the integrated water with the degree of recovery curve

2.4 Reasonable injection and production ratio of the main considerations and considerations

Considering non-mean value, water consumption, reserve retention, development effect, oil production speed and other factors, reasonable injection ratio range of different types of blocks is figured out according to the consideration of each factor boundaries.

To figure out reasonable injection-production ratio range in different stages of different blocks. In accordance with the above considerations and factors boundaries, a reasonable injection-production ratio range in different development stage is figured out.

Table 1 Reasonable injection and production ratio of different factors

classification	0≤fw＜20	20≤fw＜60	60≤fw＜90	90≤fw≤100
Reservoir properties	Consumption30%	Consumption20%	Consumption10%	Consumption10%
Water consumption	Water consumption ratio50%	Water consumption ratio50%	Water consumption ratio30%	Water consumption ratio10%
Reserves stagnation	——	Reserves retention ratio0.5%	——	——
Development effect	——	Moisture content 60% Recovery degree 10%	——	——
Oil recovery speed	——	Moisture content 50% Oil recovery rate 1.0%	——	——

Table2-1 Different development stages of a reasonable water distribution table

Block	Water 0-20% stage considerations and results						Water 20-60% Consider factors and results					
	Reservoir properties	Water consumption proportion	Development effect	oil recovery speed	Reserves Stagnation	Integrated Consider	Reservoir properties	Water consumption proportion	Development effect	oil recovery speed	Reserves Stagnation	Integrated Consider
A	1.3	1.6	—	—	—	1.3-1.6	1.2	1.7	1.3	1.5	1.4	1.4-1.7
B	1.3	—	—	—	—	1.2-1.4	1.2	1.6	—	1.6	—	1.4-1.6
C	1.3	1.5	—	—	—	1.3-1.5	1.2	1.5	1.2	1.6	1.3	1.3-1.6
D	1.3	—	—	—	—	1.2-1.4	1.2	1.4	—	1.7	—	1.3-1.5

Table2-2 Different development stages of a reasonable water distribution table

Block	Water 60-90% stage considerations and results						Water 90-100% Consider factors and results					
	Reservoir properties	Water consumption proportion	Development effect	oil recovery speed	Reserves Stagnation	Integrated Consider	Reservoir properties	Water consumption proportion	Development effect	oil recovery speed	Reserves Stagnation	Integrated Consider
A	1.1	1.5	—	—	1.3	1.3-1.5	1.1	1.2	—	—	—	1.1-1.3
B	1.1	1.4	—	—	—	1.2-1.4	1.1	1.2	—	—	—	1.1-1.3
C	1.1	1.3	—	—	1.2	1.2-1.3	1.1	1.1	—	—	—	1.1-1.2
D	1.1	1.2	—	—	—	1.1-1.3	1.1	1.1	—	—	—	1.1-1.2

3 Conclusion

(1)The use of dual-system thinking can effectively overcome the material imbalance caused by injection-production ratio. The dual system is constructed by referring to "relief wells" and "pressure relief layers" in numerical simulations.

(2)In the same development stage of different areas or different types of reservoirs, block water consumption ratio and reserves retention ratio are not the same, resulting in the difference in reasonable injection and production ratio.

(3)The greater the injection and production ratio, the faster the oil production speed, the worse the development effect; the smaller the injection and production ratio, the lower the oil production rate, the better the development effect.

(4)Comprehensively taking into consideration non-mean value, water consumption, reserves retention, development effects, oil production speed and other factors, we can determine the reasonable injection-production ratio in different types of blocks.

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