Prediction of Water Injection Rate For Oil Production In Different Ways

Zhao Huan [1], Yin Hongjun [2] , Wang Long [2]
1. Accumulation and Development of Unconventional Oil and Gas, State Key Laboratory Cultivation Base Jointly-constructed by Heilongjiang Province and the Ministry of Science and Technology, Northeast Petroleum University, Daqing 163318, P.R.China
2. Key Laboratory of Ministry of Education.PRC, Northeast Petroleum University, Daqing
E-mail:zh_cindy@163.com

Abstract: Current spliting method of production status of oil producer is based on the dynamic method of reservoir engineering principle , but influenced by various factors , and without not good effect of appication. Dynamic division equation comprehensively considered geologic and exploitation factors, including interval permeability, effective net sand, injection to producing well, injector producer distance, measure reconstruction factor and location factor and so on. Applying to the Zone D16 with this method, we can get rational single zone injection. Verify the accuracy through the comparison of the entry profile data, flow capacity and effective thickness. It's a reference to injection adjustment of similar zone.
Keywords: Dynamic division equation; Split coefficient; Water injection; Production

1. Introduction

The method of studying sublayer use condition is based on balanced injection and production rate. The quantity of separate zone water water injected is assigned to all single layers according to reservoir conditions and mining conditions of the injection wells and production wells which connect them. The information of single layers' liquid production of the producing wells and the water cut in oil wells and etc. can be got. When carving up the water injection rate, there are several ways as follow to study the divides coefficient[1-3]. (1) Water absorption profile coefficient method (2) static split formation Coefficient(KH) or the flow coefficient of the split method (3) efficacious thickness method (4) dynamic split equation.

The newest advances in prediction methods of water injection rate for oil production is the dynamic split equation principle and the law of equivalent percolation resistance . The calculation of split water is the basis of field performance analysis and the key to this block dynamic analysis. The field production splitting should be directed by the splitting result[4]. There are some water injection profiles information of Block D in the Yu Shulin field. In this research, split the water injection in different ways, compare with the information and at last choose the most effective, reasonable and accurate way to direct the field production.

2. Dynamic split equation principle

Based on fluid mechanics in porous medium, we analyze the dynamic and static factors affecting the water infection and get the dynamic split equation as follows,

$$C_j = Y_i \Big/ \sum Y_i \tag{1}$$

In the equation, Yi is a sublayer split factor. According to the actual characteristics of the studying Well block, interval permeability, effective pay thickness, the number of injection-production wells, the distance of injector and producer , measures to transform coefficient and position coefficient are the main influence factors of building split coefficient.

$$Y_i = K_i H_i M_i N_i \alpha_i \Big/ \ln\left(D_i\right) \tag{2}$$

In the equation,
K_i——interval permeability. μm^2;
H_i——effective pay thickness, m;
M_i——measures to transform coefficient, non-dimensional
N_i——the number of injection-production wells;
α_i——position coefficient, non-dimensional
D_i——injector producer distance, m.

(1) Interval permeability

Interval permeability (K) is one of the main geological factors influencing reservoir physical property. It's mentioned in many methods that interval permeability is a factor as splitting coefficient. The greater the values of interval permeability, the bigger the splitting coefficient will be and further more the interval split water will increase. On the contrary the split water will decrease. It has been confirmed in the injection profile test materials. But the combinational relation of the interval permeability and effective thickness has a different impact of interval water injection. Water injection cannot be decided by interval permeability only for poor permeability well block.

(2) Reservoir effective thickness

In general, the greater the values of interval permeability, the splitting coefficient will be bigger and interval split water will increase. On the contrary the water will decrease. Usually the interval split coefficient is calculated with product KH (formation coefficient) of permeability and reservoir effective thickness. It is correct for most homogeneous formation and is confirmed by most oil field. But in combination with the actual situation of the field, count up the actual data and come to a conclusion: When the product KH is a constant value, there're two cases: (1) When K is bigger and H is less, dynamic reflect works first in general and may inject water circularly; (2) When K is less and H is bigger, dynamic reflect is hard to work generally. Therefore, for the non-homogeneous formation, split coefficient can't be calculated by injection wells reservoir effective thickness or formation coefficient separately.

(3) The distance of injector and producer

Actually to some extent, The distance of injector and producer reflects pressure gradient size between injector-producer wells and pressure loss situation[5-8]. Under the condition of same water injection, injection-production well spacing is smaller, the smaller the resistance of filtration and the pressure loss between the injection-production well and the easier for the injected water to flow to the production well. The split water of the layer will become more and on the contrary less. In a word, water quantity is inversely proportional to the injection-production well spacing split coefficient shaped in Inform (*D*).

(4) Transforming measures coefficient

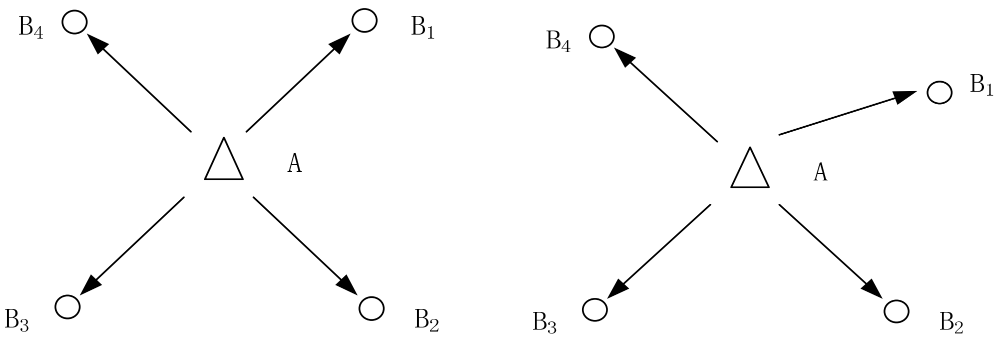
Transforming measures of injection are an artificial transform for poor interval permeability well sections or the ones which are seriously polluted and unable to inject water. After the transform, permeability and fluid ability in the immediate vicinity of wellbores get stronger and the quantity water in the stratum become larger. Transforming measures coefficient (M) is a coefficient which describes transform results. When M is bigger, the bigger the split coefficient and the more the split water quantity. We can get the value of M by reseaching transforming measures of the area. For example, according to the statistics of the DaQing oilfield, the production will increase twice and M becomes two after the fracture. The M of the layers without fracture is one and for water plugging layers M equals zero. When the producting time becomes longer, transforming measures coefficient will gradually get smaller. It can be decreased which depends on actual injection allocation condition and this will be more practical.

(5) The number of injection-production wells

The number of injection-production wells (N) reflects the number of directions of the injected water in the layers. It influences the injection allocation of single layer a lot. The number of the injection-production wells becomes more which means connection wells are more. Correspondingly, the injection allocation is more to maintain the reservoir pressure to meet the need of oil well production [9].

(6) Position coefficient

When the relative position of the inject wells and production wells around is different, seepage area is different. Under the same conditions, the flowing of wells are not the same which location coefficient shows. The bigger the location coefficient is, the larger the seepage area and the larger of the split water quantity of the direction. Such as, for the standard five point water injection, the relative location coefficient of injection well and the other four production wells around is one (It means all other things being equal, the flow of every direction is equal.). But for non-standard pattern or irregular injection-production well spacing, even under the conditions that all other things are same, the production wells flow may differ from each other. The relative location of wells around is uneven which results in the asymmetry of the flow as is shown in Fig. 1.



(a) Streamline symmetrical (b) streamline asymmetric

Fig. 1 symmetry distribution

For this case, we can describe with the included angle θ between the two angle bisectors which is respectively between the mainstream line and the two groups of injector-producer mainstream lines in the adjacent and this is shown in the Fig. 2.

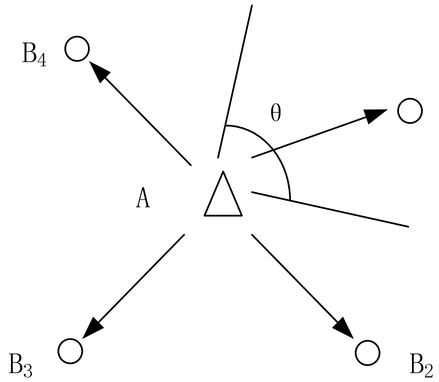


Fig. 2 the mainstream line angle bisector angle

The values θ are the same for the standard or symmetrical streamline injection-production well spacing. But for asymmetric streamline type, the values θ are different. We describe position coefficient which is because of different relative location as the following formula.

$$\alpha_{ik} = \sqrt{n \times \theta_{ik} / 360} \quad (3)$$

In the equation,

n——the number of benefit production wells around;

θ_{ik}——the angle between the water well i and the oil well k, degree.

α_{ik}——location coefficient of the water well i and the oil well k, zero dimension.

3. The block geological features

The wellblock D16 lies in the north of Y oilfield which is near the well block S382 in the south and the block D18 in the east. The main development formation is the oil layer FY. The oil-bearing area is 11.0km^2. The geological reserves are 960.28×10^4 t and the recoverable reserves are 268.84×10^4 t. The development of reservoir limited thickness on average is 14.3 m. The average porosity is 0.135 and the average air permeability is 4.47×10^{-3} μm^2. It is a fault lithologic composite reservoir.

The sand body in the block is in the single layer F. Other small scale land bodies sporadically develop. Among them the continuity of Fuyu reservoir sand body is good and effective thickness concentratingly distribute in the central of the block. The land bodies of layer Y are isolated and dispersive and effective thickness develops in the block sporadically which aren't continuous.

The oil production rate of block D16 comes down every year. The moisture keeps a rising trend. The water of well block breakthroughs rapidly and flooding effect is poor. It needs to strengthen the structure adjustment of water injection between the interlayer and plane to improve the effect of water flooding.

4. Application instance

The effective thickness method namely splitting water based on the principle of water injection and effective thickness are related. Formation coefficient method namely splitting water based on the principle of water injection and stratigraphic coefficient are related.

Before the split of small layers of water quantity in injection wells, settle the dynamic injection profile data and static geological information of the block. According to basic data and calculation formulas, split respectively according to the method of effective thickness, formation coefficient method and dynamics split equations[10] for different wells.

Comparing the split results of each well with the existing injection profile data mapping, dynamic split equation calculation results in good agreement with the actual test data is better. The results are shown in Fig. 3.

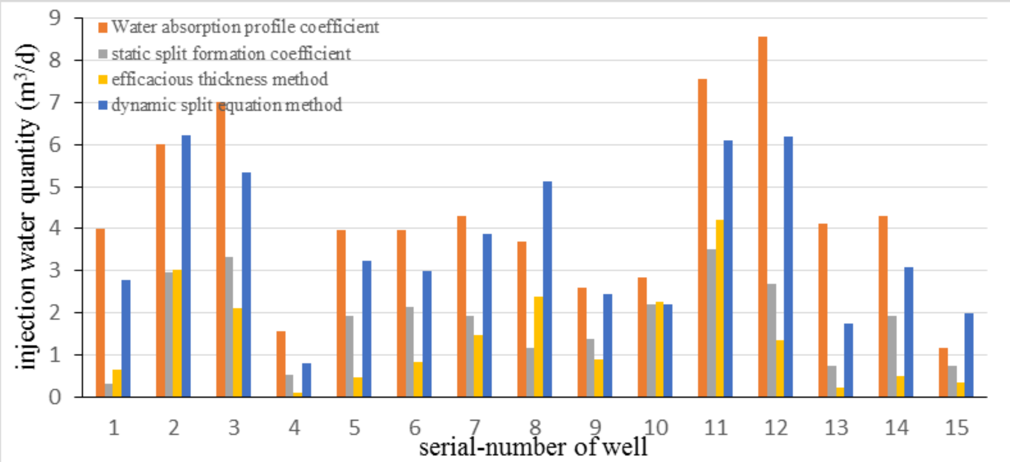


Fig.3 Injection allocation quantity contrast table

The error analysis of the sequence is shown in table 1.

Table 1 The error analysis of the sequence table

	static split formation Coefficient	efficacious thickness method	dynamic split equation
total relative error	10.3	8.45	3.84

5. Conclusions

(1) Based on splitting the water of D16 blocks respectively using the method of effective thickness, formation coefficient method and dynamic split equation method and compared with the existing injection profile data to realize dynamic split equation is more accurate.

(2) Dynamic split equations consider the influence factors comprehensively and the results of the split water are accurate and reliable. It has a good reflect of the actual suction conditions underground and has reference significance to the adjustment of water injection in similar blocks.

6. References

[1] YU Hongwen. Discussing on calculation production of stratfield fluid volume (oil) by the layered injection water[J]. Petroleum Exploration and Development, 1990,02: 47-55.

[2] ZHU Yidong. Research of single well injection allocation methods in Chaheji[J]. Southwest Petroleum University, 2005.

[3] LI Junzhi. An advanced stratified fluid volume split method [J]. Oil and Gas in Tuha Oilfied.2008, 01:31-35.

[4] HU Xuefeng, Li Jinggong, Wu Changhong, Zhang Hongxia, Gao Shujuan. Injection wells layered accumulated water quantity dynamic split method [J]. Well Logging Technology, 2004, 05:465.

[5] Asheim, H., Maximization of Water Sweep Efficiency by Controlling Production and Injection Rates, SPE 18365.

[6] Analysis of Well-to-Well Tracer Flow to Determine Reservoir Layering. Maghsood Abbaszadeh-Dehghani, SPE 10740, Stanford USA. 1984. 10.
[7] QIAN Defu, SONG Kaoping, ZHANG Chengshi. Dynamic Split Method of Stratified Water and Pressure Prediction. Geology and Development of Daqing Petroleum. 1995,02:17-21.
[8] SHANG Guanyongliang, ZHAO Dongjie, Songjie, Anzhen. Reasonable Injection Allocation Methods of Injection Wells[J]. Geology and Development of Daqing Petroleum., 2003,03:40-42.
[9] HUANG Lirong. Injection Allocation Method Research of Oilfield Developent of Injection Well[D]. Southwest Petroleum University,2006.
[10] XIONG Xindong, YANG Jianjun, Liukun, LI Xiaoming. Using the Split Coefficient Method to Determine the Injection Allocation of Single Well Water Injection[J]. Fault Block Oil and Gas Fields,2004,03:56-59.