Analysis of influencing factors of production decline of water drive reservoir

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Abstract

The oilfield development has gradually stepped into the stage of water flooding along with polymer flooding, the production structure is getting more and more complicated day by day, and new characteristics have shown need up in the change of water flooding production, therefore, the prediction of the oil field development indexes has become more and more difficult. In this paper, in the study of water flooding oil production decline, in addition to consider the influence of new wells and measures, also consider the effect factors of production decline of the plugging, the utilizations, the drilling drop and so on, which due to the intervention of polymer flooding. Correction of water flooding production decline equation, get the real decline rate of water flooding, the latter has important guiding significance to production prediction and reservoir planning.

Keywords

Production decline; water flooding; polymer flooding; plugging; utilization.

1. Introduction

Natural decline of water-drive pool oil offtake refers to production decline purely caused by rise of water content after various production decreasing or increasing factors influencing declining are eliminated [1-3]. While many of the factors having an effect on law of natural production decline are hard to be described quantitatively due to time dependence [4-7]. Therefore it is of great significance for reservoir management to analyze influencing factors of production decline rate, research influence of single factor and determine dominant factor influencing decline of production [8].

When development of oilfield gathers pace, new characteristics arise in the exploitation, as many oilfields enter the stage of simultaneous exploitation of water drive and polymer flooding, and distribution of underground oil and water becomes more complicated, plus interaction of multiple well pattern, the exploitation object becomes worse due to influence of entry water drive's cooperating with tertiary recovery blockage and utilization, etc. [9-10], which renders analysis of actual decline of water drive more difficult. To cope, it is urgently needed to research production change in two-drive condition and explore laws of production decline during utltra-high water-cut stage. Based on the actual conditions in development of the field at present, the paper researches the related factors influencing water drive decline and restore the natural decline rate of real water drive according to change of exploitation condition in oil field.

2. Analysis on influencing factors of field output declining rate

The section headings are in boldface capital and lowercase letters. Second level headings are typed as part of the succeeding paragraph (like the subsection heading of this paragraph). All manuscripts must

be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. When receiving the paper, we assume that the corresponding authors grant us the copyright to use. So-called production decline rate refers to change rate of yield in unit time, while natural decline refers to the production decline rate when there is no new well put into production and various production stimulation measures, with expression as follows:

$$D_N = \frac{Q_{i-1} - (Q_i - Q_{xji} - Q_{csi})}{Q_{i-1}} \times 100\% \quad (1)$$

Natural decline rate reflects the actual situation of oil field decline, which is directly related to oil layer type, stage of water contained, oil recovery rate, yield construction, etc. Due to influence of factors such as water drive cooperating with tertiary oil recovery blockage and utilization, etc., the factors of blockage, utilization and drill dropping, new well, etc. should be considered in researching factors influencing water drive production decline. As declining rate and the influencing measures have nonlinear relation, the relation between factors and production decline cannot be established by a simple expression. Therefore the paper analyzes the influence degree of the factors on production decline one by one on the basis of researching production decline in actual block.

2.1 Influence of new well last year being not exploited this year on production decline

After two and three adjustments to the oil field, physical property of perforated oil layer is worse, productive capacity is lower, and contribution to substitution decline dwindles away. Thus the productive capacity of new well contributes more and more to water drive yield year after year. The analysis shows that production decline of old well being aggravated caused by new well is because high output of new well raises recovery rate of oil pool, leading to increase of declining rate [1]. This part of output should be deducted to more truly reflect decline of old well water drive in calculating water drive decline. Its influence on decline is expressed as:

$$D_N = \frac{(Q_{i-1} - Q_{\text{snxj}}) - (Q_i - Q_{xji} - Q_{csi} - Q_{snwcsi})}{(Q_{i-1} - Q_{snxj})} \times 100\% \quad (2)$$

The influence of new well last year being not exploited this year on production decline is as shown in table 1.

Table 1 annual production capacity control over the calendar year under the circumstances of natural decline

time	Nii oil production (10^4t)	Production wells increased production last year (10^4t)	Slow down the decline of water drive (%)
2012	7.1	18.4	1.9
2013	5.2	17.3	1.7
2014	0.8	14.7	1.6
2015	5.0	3.9	0.5

The new well being put into production buffers decline of water drive, while it is observed from the values that as new well is put into production, the influence of newly established productive capacity on buffering water drive decline wanes year after year. The calculated decline value will be larger if this factor is not considered in calculating production decline of water drive.

2.2 Influence of water drive reserves converting to polymer flooding on natural decline

After polymer flooding is put into development, each development index changes to some degree. Generally speaking, after polymer flooding is put into production, water drive block declines more, and the increasing speed of water contained is expedited. As base of water drive reserves decreases and

water drive continues to convert to polymer flooding, further decline of structure proportion of oil produced by old well will more influence the water drive decline when water drive rolls out the same reserves, which will increase water drive decline.

Water drive reserves transfer can be divided into two conditions, one is the influence of water drive well converting to polymer flooding on production decline of water drive, another is the influence of polymer flooding blocking water drive target layer on natural decline of water drive. The expression of its influence on decline is (utilization is the same with blockage):

$$D_N = \frac{(Q_{i-1} - Q_{fdi\text{-}1}) - (Q_i - Q_{xji} - Q_{csi} + Q_{fdi})}{(Q_{i-1} - Q_{fdi\text{-}1})} \times 100\% \quad (3)$$

Then the influence of blockage and utilization on production decline is as below(table 2- table 3)

Table 2 the effect of the use of well on the decline of water drive

Time (a)	2007	2008	2009	2010	2011	2012	2013	2014
Use effect decrease (%)	-0.79	-0.54	-0.01	0.00	0.00	-0.25	-1.25	-0.01

from 2006 to 2015, utilization increases decline of annual output in each year by 0.31%,

Table 3 Effect of plugging on the decreasing of water drive

Time (a)	2007	2008	2009	2010	2011	2012	2013	2014
Blocking effect t decrease (%)	-0.21	-0.36	-0.62	-1.14	-0.80	-0.38	-2.38	-1.16

From 2006 to 2015, polymer flooding blockage and water injection increase water drive decline by 0.93% averagely

Therefore, in calculating water drive decline, the calculated decline value is smaller if the influence of blockage and utilization on water drive decline is not considered.

2.3 Influence of well drilling on natural decline

During the drilling of tertiary oil recovery well in oil field, well shutdown has a greater influence on production decline, and leads to quick increase speed of water contained. As production decline is much influenced by change of water contained, well drilling both influences yield and water contained, leading to increase of water drive production decline. The expression of its influence on decline is as follows:

$$D_N = \frac{(Q_{i-1} - Q_{\text{zgi}-1}) - (Q_i - Q_{xji} - Q_{csi} + Q_{zgi})}{(Q_{i-1} - Q_{\text{zgi-1}})} \times 100\% \quad (4)$$

Table 4 Effect of drilling and closing on the decreasing of water drive

time	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Effect on Yield(10^4t)	12	9	8.7	30	21	14	15	11.5	8.4	8.6
Decline rate effect(%)	2.95	0.19	-0.04	-2.94	0.98	0.95	-0.28	0.23	0.48	-0.17

Influence of well drilling on theoretical decline presents irregular distribution. The reason to explain this is the influence of well drilling on decline is embodied in presence of uncertainty in influence of well drilling on natural decline rate during two years. However, owing to well drilling decreasing the oil offtake in current year, we can know that well drilling will increase water drive decline from improving the water content in the current year.

2.4 Influence of change in produced fluid on natural decline

Oil recovery rate is one of important development indices to determine the effect of oilfield development, which can only be guaranteed by a proper rate. Thus to research theoretical oil recovery rate and influencing factors is of crucial importance to production decision of oil field. When the speed of produced fluid is unchanged, the natural decline is proportional to the product of oil recovery rate and increased rate of water cut under condition of certain water being contained, while oil field conducts extraction production to guarantee stable output, which decreases water drive decline. Its influence on decline is expressed as:

$$D_N = \frac{(Q_{i-1}) - (Q_i - Q_{xji} - Q_{csi} + Q_{snxji})}{(Q_{i-1})} \times 100\% \quad (5)$$

Table 5 Effect of liquid production on the decline of water drive

time	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Effect on Yield(10^4t)	22.3	-25.6	3.9	0.4	4.8	8.8	8	-12.9	27.4	-10.8
Decline rate effect(%)	-2.99	0.5	0.05	0.71	1.31	1.19	-1.96	4.65	-1.81	-2.99

Extract production in later period of oil field development, an effective measure to keep stable output, will buffer the decline rate of water drive in current year. The calculated decline value is smaller if the influence of extracting on water drive decline in calculation of water drive decline is considered, while theoretical natural decline is greater if influence of produced fluid is not considered.

3. Reduction of actual water drive natural decline rate

To sum up, due to influence of oil production structure in the development of oilfield, the influence on each part of yield should be reduced in researching water drive decline to get actual water drive decline rate, with expression as follows:

$$D_N = \left(1 - \frac{(Q_i - Q_{xji} - Q_{csi} - Q_{snxji} + Q_{lyyxi} + Q_{fdyxi} + Q_{zgyxi})}{Q_{i-1} - Q_{xji-1} - Q_{fdci} - Q_{lyci} + Q_{zgyxi-1}}\right) \times 100\% \quad (6)$$

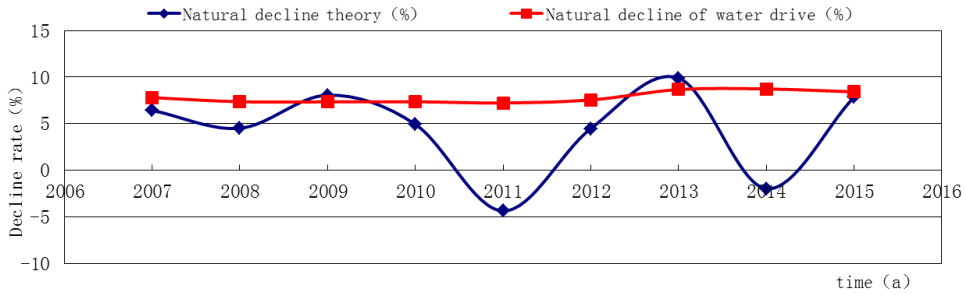

Fig. 1 Comparison of reduction rate and natural decline of real water drive

Where: D_N is natural decline rate, %; Q_{i-1} is oil offtake in last stage, 10^4t; Q_i is oil offtake in current stage, 10^4t; Q_{xji} is the output from new well in current stage, 10^4t; Q_{csi} is the output from the measures in current stage, 10^4t; Q_{xji-1} is oil offtake from new well in last year, 10^4t ; Q_{lyci} is the oil offtake from utilization in last year, 10^4t; Q_{fdci} is the oil offtake from blockage in last year, 10^4t; Q_{fdyxi} is the oil offtake influenced by blockage in current stage, 10^4t; Q_{snxji} is the oil offtake from the measures in the end of this year on new well in last year, 10^4t; Q_{lyyxi} is the oil offtake influenced by utilization in current

stage, 10^4t; Q_{zgyxi} is the oil offtake influenced by well drilling in current stage, 10^4t, Q_{lyyxi} is the oil offtake influenced by utilization in current stage, 10^4t.

4. Conclusion

In addition to water content, water drive natural decline is also influenced by blockage, utilization, well drilling and new well, etc. With gradual rise of recovery percent of reserves, the object of reservoir exploitation gradually becomes worse, and development type is also converting to tertiary oil recovery from class I and II reservoir, leading to decrease of water drive reserves degree by degree, and increase of production decline year after year. To reduce actual water drive decline rate with multiaspect factors considered is conductive to forecast of field output and output planning in later stage.

Figure 1 tells us the longer the oil field keeps stable output(keeping unchanged decline rate), the higher the production decline rate in the end of stable production period.

References

[1] Zhang Yigen. Factors affecting the production decline of fault block oil reservoir in Shengli Oilfield [J]. oil and gas geology and oil recover. 2007,14(03);90-93.

[2] Zhang Xiongjun, Cheng Linsong, Li Chunlan. Application of grey correlation analysis method in the analysis of the influence factors of production decline rate [J]. oil and gas geology and oil recovery,2004,11(6):48-50.

[3] The main practice of [J]. special oil and gas reservoir in the high speed decline period of the 102 fault block of the king of the party,2004,11(1):49- 52.

[4] Zhao Xiao Yan, Chuan Zhi Cui, Wang Bao, Yang Yong, Niu Shuanwen. Water flooding reservoir yield diminishing returns factors diagnosis model [J]. Southwest Petroleum University Journal (NATURAL SCIENCE EDITION).2009(04),99-100.

[5] Ma Xiansheng, Hou Pingshu, Jia Fuze, et al. In Qiaokou oilfield natural decline factor analysis and Control Countermeasures of [J]. PGRE,2002,9(5):47- 48.

[6] Shen Yingnan. Study on the natural decline rate of old wells in Zhongyuan Oilfield [J]. fault block oil and gas field ,1995,2(6):16- 23.

[7] Zhang Guosong. Shanshan oilfield natural decline factor analysis and Control Countermeasures of Tuha Oil and gas [J].,2005,10(1):26- 28.

[8] Yan Wenhua, Zhao Yushuang, Wang Hongyan. The factor analysis and control strategy of production decline in the peripheral oilfields of Changyuan Daqing [J]. petroleum geology and Engineering .2007(05)

[9] The law of water flooding development in the ultra high water cut stage in the development zone of Zhang Jiping [D]..SZ Daqing Petroleum Institute 2009,1

[10] Yuan Junxiang, Li Bin. Factors affecting the production decline rate and the way of slowing down [J].. 1997(03)

[11] Miu Feifei, Zhang Hongyou, Liu Xiaohong, Zhang Yanhui, Mou Chunrong, Dai Weihua. Study on the law of natural decline of production theory of water drive oil field [J]. petroleum geology and engineering.2014(01)