Comprehensive treatment strategy for high water cut stage of medium and low permeability reservoir

Hui Xue

Institute of Geology, No.4 Oil Production Plant, Daqing Oilfield Co., LTD., Daqing Heilongjiang 163500, China

Abstract: Maintaining good conditions for petroleum exploitation is an important basis for achieving better exploitation results. At present, the main reservoir conditions of our main oil fields are relatively good, and have entered high water cut, middle and late development. Due to long-term exploitation, the reservoir has suffered a certain degree of destruction, resulting in the rapid rise of aquifers and sharp reduction of production. It has certain influence on the output of oil and well and the final recovery efficiency of oil field. In order to alleviate the contradiction of rapid reduction of oil production pressure and output in high water cut stage of medium and low permeability reservoir, the development efficiency of reservoir can be improved. By analyzing the high water cut stage of medium and low permeability reservoir, this paper puts forward the comprehensive treatment measures, which provides the idea for realizing the increase of production.

Key words: Medium and low permeability reservoir; High water content; Treatment strategy

1. Introduction

From a supply point of view, in addition to actively seeking new sources of oil and gas, both domestically and internationally, existing resources should be actively exploited to improve the efficiency of crude oil extraction. Increasing the crude oil production of existing oil and gas fields is of great significance for ensuring the safety of oil and gas resources and improving the exploitation efficiency and sustainable development of oil and gas resources. In the process of the continuous development of oilfield development in the high water cut stage, the calculation of geological reserves in the 1980s and off-balance sheet reserves in the 1990s can no longer meet the needs of current oilfield development [1]. Therefore, it is of great theoretical value as well as practical value to study the corresponding treatment countermeasures for the problems existing in the middle and low permeability reservoirs in the high water cut stage.

2. Main problems in high water cut stage of medium and low permeability reservoir

With the arrival of high water cut stage of medium and low permeability reservoir, the problem of rapid decline of recovery rate appears, which affects the in-depth study of oil stability and water control technology on reservoir. Taking the first North area of Daqing Oilfield as an example, the main problems are as follows:

2.1 Imbalance between reservoir and oil production reduces reservoir productivity

After primary and secondary encryption, and several large-scale water transfer, oil stabilization and water control measures, the remaining recoverable reserves of Daqing Sazhong Oilfield have increased from 7.77% to 9.20%. The reserve-production ratio of the field dropped from 12.87 to 10.8, and the possibility of increasing reserves became less and less, and the decline became larger and larger (Figure 1).

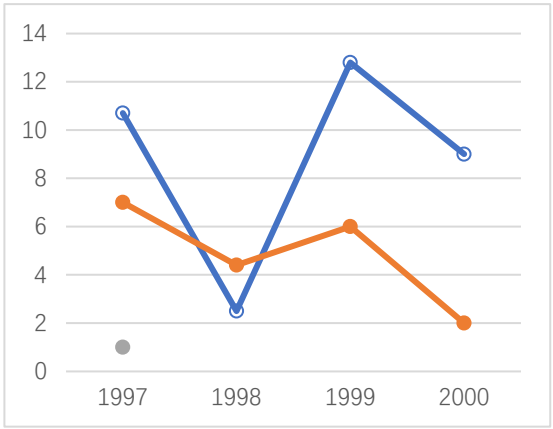

Figure 1. Oil field savings

2.2 The difference of water content in different strata becomes smaller, which increases the difficulty of water control

The difference of water content in the eastern part of the first member of the North fault decreased from 10.3% to 9.07% in the 1990s, and then to 2.48% in 2004. In the past 14 years, the comprehensive water cut in this region has only increased by 5.54%, with an average annual growth rate of 0.39%, which significantly inhibits the growth rate of water cut in this region. The possibility of further restraining the growth rate of water cut through structural adjustment in the future is very slim, and the growth rate of water cut will increase if no effective water control measures are taken.

2.3 The speed of casing damage increases, and it is difficult to control casing damage

After the second infill adjustment, the annual injection-production ratio of the first area in North China has been maintained at 1.52-1.24, and the cumulative injection-production ratio of 1.22 has been maintained at a high level for a long time. Before treatment, there were 103 overlying pressure injection Wells [2]. The intense waterflood development kept the formation pressure in the eastern block at the same level, and the total differential pressure in the block reached 0.21 Mpa before it was effectively controlled. Over time, the number of casing losses has increased. By 2000, the cumulative number of Wells had reached 238, and the rate had increased from 0.26% to 4.18%. With the increase of production, the control of casing damage becomes more and more difficult. (Figure 2).

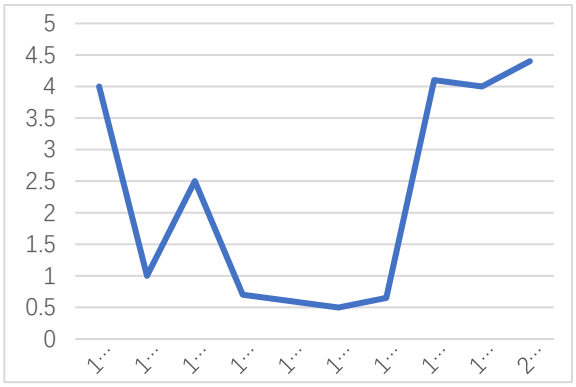

Figure 2 damage rate

2.4 High degree of transformation and low potential for increasing production

Today, the fracture rate of the old well is more than 71%, 90.8% of the Wells were re-fractured after the first confining fracturing, and 32.3% of the Wells were re-fractured after the second infill fracturing. To date, 54.3 percent of the Wells have been fractured, and nearly half of those Wells have been re-fractured. Recurring Wells accounted for 81.4 percent of all Wells. A set of tanks has a low potential for further development and adverse effects after eliminating factors such as compartments, flooded zones, cementing quality, and production techniques. The stimulation water yield per well was also increased from 68.9% to 81.2%.

2.5 Remaining oil with multiple reservoirs and high water cut that is difficult to excavate

Based on the data of three oil production Wells in the first North Area, it is concluded that the thickness of the eastern part of the fault is 83.5-87.7%. It was confirmed that the first and second oil reservoirs were flooded with water, and the degree of water erosion was large, accounting for 69.3%. In the thin differential layer, the number of scouring layers accounted for 78.8%, the thickness of sand layer accounted for 81.2%, the effective thickness accounted for 85.4%, and the scouring rate of surface layer accounted for 20.5%[3]. This shows that the residual reservoir in this area is very small, and it is very difficult to study and develop it.

2.6 Water injection and liquid production increase with the rise of water cut

In order to ensure the stable production of the oilfield under the condition of increasing water cut and accelerating production decline, measures to increase the water injection rate were continued in the east section of the first section of North Section. The annual water injection rate increased by 29.62.3 percentage points and the annual liquid output increased by 36.56 percentage points. Resulting in oil and gas field operating costs continue to increase, oil and gas field exploitation economic benefits decline. In order to explore the possibility of continuous improvement of oil recovery in high water cut stage of middle and low permeability reservoir, Sazhong Oilfield in Daqing has carried out regional comprehensive consolidation analysis on two fault blocks in the east and west of North No.1 Block. In order to realize the sustainable development of reservoir, it is discussed to improve the oil recovery in the high water cut stage of medium and low permeability reservoir.

3. Comprehensive treatment strategy

With the continuous improvement of the development degree of water drive reservoir, it is necessary to adjust the water drive reservoir after the high water cut period in order to control the water cut of water drive reservoir and make the production of water drive reservoir increase steadily. The well pattern deployment, injection-production relationship, and water flooding development effect in the development process are studied in detail (see Table 1), and the development layer is studied in detail, including porosity, permeability, oil saturation, etc. On this basis, the development prospect of the remaining oil in the oilfield is analyzed by using stratification, quantization, water flooding and other methods [4].

Table 1 Development layer parameters

No	Classification index	standard				
		A class	B class	Cclass	index	class
1	Control degree of water drive reserves /%	≥70	70-60	＜60	71.02	B
2	Injection-production correspondence rate /%	≥65	65-45	≤45	42.34	C
3	Energy retention level and energy utilization degree	increase	steady	decrease	reduce	C
4	Water drive recovery factor /%	≥30	30-20	≤20	29.0	B
5	Rate of recovery of recoverable savings /%	≥7	6.9-6	＜6	0.6	C
Comprehensive evaluation result						C

3.1 Reasonable well pattern layout and injection-production ratio

In the oil field of water drive development, the displacement of water in the water injection well is used to promote the smooth exploitation of oil flow in the oil well. It is necessary to adopt reasonable well pattern layout, improve the well pattern system, infuse it, and adjust the injection-production relationship, so that the well pattern density can be selected properly. Reasonable control should be carried out on the ratio of injection-production Wells, as long as water flooding can be achieved. If water injection is carried out too early, the oil reservoir will see water in advance or be flooded, thus losing the value of exploitation.

3.2 Cement sealing

Want to do a good job of technical support, make the production technology to better serve the oil and gas fields. For the technical measures supporting the development of the high water cut stage in the low permeability oilfield, the liquid flow in the well can be extracted to the surface by means of fluid extraction. In addition, cement plugging technology can be used to seal off discovered aquifers to unlock remaining geological reserves and increase field production.

3.3 Periodic water injection test

One of the important reasons for the influence on the oilfield development results in the high water cut stage of medium and low permeability reservoir is to study the heterogeneity of the reservoir through the periodic water injection test. In order to overcome the heterogeneity of the reservoir, the method of periodic water injection was tested in the water injection well. After injecting for a period of time, the water injection was stopped and observed, so that the high permeability area could see water in advance. Then, when the energy has dropped to a certain level, the next cycle is filled with water so that the effect is achieved and the oil is removed.

The development effect of periodic waterflooding is better than that of continuous waterflooding. The research shows that under the same water cut, the recovery degree of periodic waterflooding is higher than that of continuous waterflooding. The recovery factor of periodic waterflooding was 0.605% and that of continuous waterflooding was 0.573%. The improved recovery factor of periodic waterflooding was 3.2960% compared with that of continuous waterflooding. The results showed that there were many forces besides the displacement force, such as capillary force, elastic force and gravity force. In the process of periodic injection, the influence of capillary force is the first, followed by the influence of elastic force, and the influence of gravity on the process of periodic injection is not enhanced or weakened. The numerical results show that under traditional water flooding conditions, the pressure at the high and low permeability points is uniform due to the inhomogeneity in the formation. However, in the half cycle of periodic water injection stopping or reducing, the pressure at the high permeability decreases rapidly, while the pressure at the low permeability decreases slowly due to the difference in oil saturation and permeability. This causes the high osmotic pressure to be lower and the low osmotic pressure to be higher at the same time, creating an additional pressure difference between the two locations, so oily water moves from the low osmotic pressure with higher oil saturation to the high osmotic pressure. During the half-cycle of re-injection or increased water injection, the pressure at the high permeability site recovered quickly, while the pressure at the low permeability site recovered slowly, creating a reverse additional pressure difference. Meanwhile, in turn, the oil water flowed from the high permeability site and the oil saturation was lower than that at the low permeability site, which increased the formation pressure at the low permeability site. In the next cycle, More oil flows from low-permeability sites to high-permeability sites to conserve energy. Thus, in a complete cycle, a large amount of water is lost from the high permeability to the low permeability, and more oil flows from the low permeability to the high permeability, which expands the sweep volume of water flooding and improves the development effect of water flooding.

Similarly, under conventional waterflooding and multizone combined production conditions, the reservoir with high permeability is reduced faster than the reservoir with low permeability within half a cycle of stopping waterflooding. In the injected water recovery process, the pressure of the bad layer is higher than that of the good

layer, the liquid production of the bad layer is improved, the water recovery rate of the good layer is better, the pressure drop of the bad layer is lower than that of the good layer, and the water absorption capacity of the bad layer is improved [5]. This changes the pressure distribution of the formation again and again, thus improving the development efficiency of the reservoir. Similar to intra heterogeneous reservoir, periodic injection can also cause cross penetration of high and low permeability intervals in plane, but its effect is less than that of intra heterogeneous reservoir. However, as long as the permeability level difference between high and low permeability zones is large and there is a large contact surface, the remaining oil in the low permeability zone will flow to the high permeability zone, so as to obtain higher recovery efficiency.

3.4 Polymer Injection

Through polymer injection, the viscosity of the injected water is increased, the sweep volume is expanded, and the displacement capacity is improved to increase the oil production. The technical measures to enhance oil recovery, polymerization agent, ASP flooding and CO2 flooding were adopted to increase production.

4. Conclusion

It is a common phenomenon for oil Wells at home and abroad to have high water cut in medium and low permeability reservoirs. In the high water cut stage, the oil field output is small and it is difficult to meet the actual production demand. Based on the actual situation of North No.1 area of Daqing Oilfield, this paper puts forward the comprehensive treatment measures for the oil development of middle and low permeability reservoirs in the period of high water content, partly solves the problems of development difficulty, and brings beneficial changes to ensure the normal production of oil fields and improve economic benefits.

References

1. Hong Yafei, Sun Dongsheng, Luo Yuhan, Tang Yun. Study on remaining oil distribution of low permeability thin interbedded reservoir in high water cut stage [J]. Complex Oil and Gas Reservoirs, 2022,15(02):72-77.
2. Zhang Lishuang. Optimization method of well pattern density in the late stage of high water cut development in low permeability reservoir: A case study of Area X [J]. Chemical Engineering and Equipment,2020(09):51-54.
3. Lin Rushan. Low permeability reservoir with high water cut period reservoir renovation technology optimization and parameter optimization research [J]. Journal of petrochemical technology, 2018, 25 (9) : 168.
4. Zhu Linlin, Fu Xianping. Study on reservoir reconstruction technology optimization and parameter optimization in middle and high water cut stage of low permeability reservoir [C]// Xi 'an Shiyou University, Shaanxi Petroleum Society.2018 International Conference on Oil and Gas Field Exploration and Development (IFEDC 2018), 2018:485-489.
5. Diao Guangzhi, Yao Xiang, Cui Wei, Dong Jie. Low permeability reservoirs of well pattern adjustment at the high water-cut stage study [J]. Journal of petrochemical industry applications, 2017, 4 (01) : 55 to 57.