Research on New Mining Technology Based on Oilfield Reservoir Water Injection

Penghui Song*
School of petroleum, University, Karamay, China
*Corresponding author email: 1226982466@qq.com

Abstract. During the development of oilfields, we usually study reservoir water injection and water injection well fracturing as two important measures to improve the effect of water flooding. These two technologies play a big role in oilfield development, but there are also some problems in the application process. In this paper, through the analysis of the fracturing mechanism and problems of reservoir water injection and water injection wells, the adjustment method of reservoir water injection and water well fracturing is proposed, which reduces the water injection pressure technology of high pressure water injection well and improves the oilfield development effect.

1. Introduction
The water injection fracturing oilfield is the most important secondary oil recovery method and method in the world. The low permeability and ultra-low permeability reservoirs bring great difficulty to the oilfield water injection fracturing due to the poor physical properties and narrowness of the reservoir. Fracturing is the most effective way to transform, but the conventional fracturing effect in ultra-low permeability reservoirs is poor. In recent years, the oil well has carried out the water well fracturing test, and has achieved a certain effect of increasing the injection. However, there are still some wells that are difficult to inject water after fracturing. In China, some water wells in ultra-low permeability reservoirs are not filled with water.

Oilfield water injection is a complex system engineering. It is based on the water quality treatment of injection water and water quality stability. Based on the protection of oil layers, it can maintain the pressure of oil layers and achieve stable production and increase production. One of the driving modes with higher recovery in various driving modes is hydraulic driving. In order to efficiently extract crude oil from the oil layer, Chinese oil fields have basically adopted the method of water injection fracturing. In addition to water injection in the oil layer, in addition to enabling the oil field to be driven by water pressure and improving oil recovery, it can also improve the development speed of the oil field. When the area of the low-permeability oil field is large, due to the shielding effect of the outer-row well, the range normally affected is two three-row wells. Therefore, the formation pressure of the internal wells of the oil field is gradually reduced. When the pressure at the bottom of the well is kept constant, the production of the well is reduced, and the development speed of the oilfield is reduced. In order to obtain a higher oil recovery speed, it is necessary to be at the waist of the reservoir. Water injection at the center and at the side.
2. Study on water injection fracturing parameters of low permeability oilfield

2.1. Low-permeability oilfield water injection timing

The use of water injection technology to develop low-permeability oil fields, the selection of appropriate water injection timing is the key to pressure-holding mining. The timing of water injection refers to the time for water injection into the formation according to a certain amount of injection after the development method of water injection is determined. Field experiments were carried out using water injection techniques in different development blocks of the oilfield. It was found that the higher the original formation pressure, the worse the formation properties and the longer the required water injection time. At the same time, as the water injection time is extended and the cumulative injection volume is increased, the single well production increases. From the angle of oil production, the water injection technology was studied. It was found that the oil production intensity decreased with time and eventually stabilized, and the final stable oil production intensity of water injection was higher than that of synchronous water injection and higher than that of delayed water injection. The effect of water injection is better, and the longer the water injection time, the higher the formation pressure recovery rate and retention rate, and the higher the stage recovery rate [1].

![Figure 1. Principles of new mining technology for oilfield reservoir water injection](image)

2.2. Low-permeability oilfield water injection

We need to derive the formula for calculating the maximum water injection volume of the injection well according to the material balance method, which indicates that the maximum water injection amount is proportional to the single well injection water use area, the average effective thickness, and the comprehensive elastic compression coefficient. The water injection intensity is related to the average formation pressure, the injection water viscosity, and the drainage area. The mathematical model of comprehensive water and cumulative water consumption and cumulative water-oil ratio in low-permeability oilfields was established, and the relationship between different water-bearing periods, oil production and reasonable water injection was derived, and the reasonable water injection volume of single well was predicted. From the perspective of field application, the apparent water absorption index curve in the oilfield production process analyzes the reasonable water injection volume of the oilfield. With the increase of water injection pressure, the daily water injection volume decreases, and the water injection increases with the increase of water injection pressure. The amplitude increases [2]. And when both of the daily water injection reaches 80m³/d, the inflection point appears in the apparent water absorption index curve. The maximum water injection should not exceed 80m³/d, and the minimum
water injection should be above 80m³/d. According to the feedback of pressure monitoring, the factors of water injection control such as reservoir fracture, heterogeneity and degree of injection are analyzed. It is found that the production of water injection well is reduced by more than 10% compared with that of unfilled well. When water injection is 3 months. When the cumulative water injection reaches 0.5% PV, the single well production has the largest increase, the recovery degree is high, and the comprehensive moisture content is low[3].

2.3. Reasonable development analysis of low permeability oilfield
The staff should combine the production characteristics of low-permeability oil fields and the form of artificial cracks to establish physical and mathematical models for better platform analysis. There are certain principles between artificial cracks and reservoirs, and the staff should understand the boundary conditions and establish a physical model. It mainly has a five-point method and an anti-nine-point well network to calculate the reservoir in the simplification of the unit. We need to maintain the oil layer pressure in the oil field, and in the water injection fracturing, it will not cause the gas content of the low permeability reservoir to decrease. In mining, attention should be paid to the flow of the two phases of water injection, and the level of the oil layer should be designed to grasp the anisotropy of permeability. When the compression system does not change, the viscosity of the reservoir fluid remains constant. We can ignore the effects of overall gravity and capillary forces, and the pressure inside the reservoir is small. In the analysis of mathematical models, we need to determine the evaluation index system and use this as an effective basis [4]. In this process, different project indicators are combined into a set of evaluation indicators, and then the parameters of the mining are determined in the overall optimization. We have to record the maximum oil recovery rate and finally calculate the recovery factor. For the no-water harvesting period, we should pay attention to the water injection volume, then determine the net present value, and finally ensure the system's investment recovery [5].

3. Low-permeability oilfield fracturing water injection and oil recovery overall optimization

3.1. Analysis of fracturing water injection technology in low permeability oilfield
The oil well network density optimization scheme mainly uses the fracturing scale to analyze the well bottom pressure of the water injection well and analyze the oil production well. Under the same diversion capacity, different well network density schemes can be used. For example, in the process of decreasing the density of the well pattern, the water seeing time of the oil well has increased. In the actual analysis, the well pattern density is 30mx30m, and the investment profit rate of the oil well is increased. The production capacity at the end of 3 years will reach 1.33m³/d, and the profit rate will be. The second is the optimization of the fracturing scale. This method is suitable for the development of natural cracks. In the simulation of the scheme, it is necessary to calculate the influence of the absence of natural cracks. When the fracturing scale of the well is 0.3 slit length ratio, the well net density, water injection pressure and bottom hole pressure of the production well should be well recorded. In the mining work, the scale of fracturing continues to increase, and the production capacity of oil wells increases, but the water seeing time is relatively short. The staff must meet the capacity and scale requirements, select the plan with the largest investment rate, and record the seam length ratio of the corner and side wells [6].
3.2. Overall optimization multi-objective design

We use orthogonal experiments to optimize the design and summarize the overall solution to reduce the number of simulations. For the overall optimization of low-permeability oil fields, the fracture orientation should be analyzed to avoid the impact on the final result. In actual mining, the possible influencing factors are: well spacing, well pattern and injection-production well, combined with the length of the crack, the conductivity, and the production pressure difference to determine the mining situation. In actual production, five variation values are selected in the parameters, and the overall optimization scheme is finally determined.

We need to optimize the injection well and bottomhole pressure with the same well pattern density, fracturing scale, and diversion capacity. The water injection pressure of the whole process is mainly 18MaP, 20MaP and 29MaP. When the bottom whole pressure of the injection well is continuously increased, the production capacity of the oil well can be appropriately increased and the investment profit rate can be increased. If the oil well sees a short time, it is necessary to clearly see the water time requirements and determine the optimal plan. In the case of well mesh density, fracturing scale, bottom hole pressure of water injection well and diversion capacity, the bottom hole flow pressure of oil wells is relatively small, generally 0.5MPa, 1.5MPa and 3MPa. In the process of continuously reducing the bottom whole pressure of the production well, the production capacity of the oil well is also continuously increased, increasing the profit of the overall investment.

3.3. Our basic countermeasures for water control and oil stabilization

The key to controlling water and stabilizing oil to improve oil recovery is to increase the area of water flooding, improve the effect of water flooding, and use the advantages of reservoirs to enhance the utilization of reservoir characteristics to achieve enhanced oil recovery. In view of the main contradiction between water control and oil stabilization in low permeability oilfields, we suggest the following measures to achieve enhanced oil recovery.

Optimize the production well network. Optimize the well pattern structure, increase the well position in the area where the crude oil is dense, reduce the well position in the area where the crude oil is less, and improve the effect of water injection and oil recovery according to the distribution of the remaining crude oil production. Optimize the water injection well network. As the mining intensity increases, many water injection wells no longer play their due role, or some well-functioning wells are no longer filled
with water, resulting in a decrease in oil recovery rate, which requires re-arrangement and optimization of the injection well location.

![Diagram of oilfield fracturing water injection process](image)

**Figure 3.** Technical points of oilfield fracturing water injection process

3.3.1. **Injection and production optimization technology.** Water injection and oil recovery should be rationally optimized. Water injection or excessive water injection should not be done blindly. To achieve reasonable water injection, water resources can be saved on the one hand and water content in the well on the other hand.

3.3.2. **Fracture multiple times.** This is the most effective measure to improve oil recovery in low permeability oil fields. During the first fracturing, there will be a large number of cracks in the underground oil layer, resulting in the crude oil not circulating. Even if the water injection volume is increased, the oil recovery cannot be improved. Especially in the later stage of development, the underground crude oil has not been greatly reduced, just because circulation leads to a decline in production. After multiple fracturing, although new cracks will form, the first part of the crack will be improved, and the crude oil will start to flow, which will improve the recovery of crude oil.

3.3.3. **Improve the technology of injection-production relationship.** Improve the injection-production relationship between production wells and wells, and adopt measures such as water shut-off in oil wells to fundamentally deal with uneven surface problems, improve water flooding capacity, and increase crude oil exploitation rate. According to the uneven characteristics of the oil layer, periodic water injection is used to make full use of the difference between the layers of the low-permeability oil field, and use its own capacity to drive the crude oil and increase the injection water area, thereby improving the oil recovery.

3.3.4. **Acidification technology.** An important problem in low-permeability oilfields is the insufficient water injection, which will fundamentally affect the recovery of crude oil. At this time, acid wells can be used to treat wells with high water injection pressure, so as to maintain the energy of underground crude oil, and it can also increase the effective area of water flooding, improve the driving effect, and fundamentally improve the recovery of crude oil.
4. Discussion on the mechanical mechanism of stress affecting reservoir ground stress

The reservoir geological body is affected by sedimentation and later tectonic movement. The rock distribution pattern is complex. The relationship between the lithologic interface and the maximum principal stress at the boundary level can be abstracted into three types: vertical, parallel and oblique. Happening. Without considering the influence of structural morphology on ground stress: when the lithologic interface is perpendicular to the maximum principal stress at the boundary level, the horizontal stress field in the reservoir changes due to the additional stress at the lithologic interface, and the stress field direction No deflection occurs; when the lithological interface is parallel with the maximum principal stress of the boundary level, that is, perpendicular to the minimum principal stress of the boundary level, when the additional stress is small, the direction of the horizontal stress field in the reservoir does not change, and the minimum principal stress increases; When the additional stress is large enough, the horizontal stress field may be turned by 90 degree, and the horizontal maximum principal stress becomes the horizontal minimum principal stress in the sand body. When there is a certain angle between the lithological interface and the maximum principal stress at the boundary level, the existence of additional stress forms shear stress on the boundary principal stress surface, and the horizontal principal stress increases, according to the vertical principal stress in the stress principal coordinate system. There is no definition of shear stress on the surface. It can be concluded that the principal coordinate system of the reservoir has been deflected at this time, and the magnitude of the principal stress in the reservoir has also changed, forming a new geostress field.

4.1. Stress effect of reservoir water injection reservoir

Stress ellipse analysis of reservoir geostress the influence of the lithologic interface and the maximum principal stress angle of the boundary level on the reservoir stress field can be analyzed by stress ellipse. The lithologic interface is at an angle from the maximum principal stress of the boundary level from 0 degree to 90 degree. It can be considered that the lithological interface rotates along the first quadrant of the boundary stress ellipse. According to the geometric relationship, the additional stress generated at the lithological interface, the component $\sigma$ at the horizontal stress $\sigma$ of any boundary is, the reservoir stress field is $\beta$, and the water injection time is $t$.

$$\beta \alpha = \begin{cases} \beta \cos (90 - \theta - \alpha) \\ \beta \cos (\theta + \alpha - \alpha) \end{cases}$$ (1)

It can be seen from equation (2) that the reservoir stress field is affected by boundary stress conditions ($\sigma_H$, $\sigma_h$):

$$\begin{cases} x = \sigma_H \cos t \\ y = \sigma_h \sin t \end{cases}$$ (2)

It can be used to calculate the stress equation modeling of oil well pressure water injection.

$$\sigma = \frac{\sigma_H^2 \sigma_h^2}{\sigma_H^2 \sin^2 \alpha + \sigma_h^2 \cos^2 \alpha}$$ (3)

We additional stress, and lithologic interface and boundary horizontal fracturing water injection angle without considering the influence of the structure on the geostress field. The combined effect of $\theta$. Under the condition that the reservoir burial depth is not large, the boundary stress conditions of the reservoir can be considered to be certain. At this time, the elliptical shape of the reservoir stress field is
mainly affected by the difference of rock mechanical properties and the maximum lithological interface and boundary level. The combined effect of the angle of stress is the same as that obtained by geomechanical analysis. Analysis of comprehensive mechanical mechanism and mathematical analysis of stress ellipse, the degree of difference in rock mechanical properties affects the magnitude of additional stress, and the additional stress changes the state of stress field in the reservoir. This is the influence mechanism of the difference in rock mechanical properties on the in-situ stress field of the reservoir.

4.2. Mechanism analysis of adjustment measures combined with water injection and profile control
There are certain problems in the practical application of reservoir water injection and water injection well fracturing. However, the reservoir water injection technology lacking the difference between high and low permeability zones and the water well fracturing technology with rapid water injection rise just form. Complementary, the combination of the two can be used in the oilfield development process to alleviate the problem of rapid increase of water injection pressure in low permeability oilfields. The mechanism of action is fracturing, a flow channel with high conductivity is formed in the well into the well. When the pressure of the injection well rises, the reservoir is injected with water, and the high water injection pressure is used to make the high and low permeability zones in the formation. Oil-water displacement is performed to replace unaffected reserves in the low-permeability layer and improve oil recovery.

5. Conclusion
China has a large number of low-permeability oil fields, rich oil and gas resources, and huge development potential. Due to the difficulty in the development of low-permeability oilfields, technological transformation and innovation are important ways to increase production and income in low-permeability oilfields. The water injection production parameters of low-permeability oilfields were studied, and many targeted measures were proposed, which achieved good development results. In the future, research efforts on water injection fracturing in low-permeability oil fields should be further increased to make greater contributions to the development of low-permeability oil fields.

References
[1] Wang Guangfu, Liao Rongfeng, Li Jianglong. Sinopec low permeability reservoir development status and prospects. Oil and Gas Geology and Recovery, 6, 13, 2017, pp.84 - 89.
[2] Che Qijun, Lei Junan, Yan Yuxia, et al. Water injection improves the development effect of ultra-low permeability oilfield. Petroleum Geology and Development, 11, 2018, pp.20 - 22.
[3] Han Li. Study on water injection fracturing in Chang 10 block of Chaoyanggou Oilfield. Petroleum Institute, (2017).
[4] Li Liang, Hu Jianguo, Qi Jihui. Water injection is an important way to develop low-permeability oil fields. Xinjiang Petroleum Geology, 6, 22, 2016, pp. 232 - 234.
[5] Zhao Chunpeng, Yue Xiangan. Experimental study on long core of water injection in ultra-low permeability reservoirs. Journal of Southwest Petroleum University, 6, 10, 2016, pp. 105 - 108.
[6] Chen Jiaxiao. Study on seepage mechanism and development technology policy of Xifeng ultra-low permeability reservoir. Chengdu: Southwest Petroleum University, (2017).