

# Study on Fracturing Technology of Water Injection Well in Low Permeability Reservoir

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**Abstract:** Affected by the difference in permeability of the water injection layer, the injection effect of each injection well layer also has a large difference, the formation permeability gradually decreases, the water injection volume also decreases, the low permeability reservoir has poor reservoir property, the oil well production is low, and the injection well water injection pressure is high and the water injection is difficult. The injection volume of the low permeability layer must be increased by the water injection well fracturing technology. The main function of the water injection well fracturing technology is to improve the water flooding volume, water absorption capacity and oil production capacity of the water injection well, and improve the oil layer utilization condition by supplementing the reservoir energy to achieve the goal of increasing single well production and even the overall block production. This paper mainly discusses the application of fracturing technology in water injection wells in low permeability reservoirs.

## 1. Introduction

The water injection well fracturing technology is developed on the basis of the fracturing stimulation principle of low permeability reservoirs. It uses fracturing fluid to form micro-cracking water near the reservoir to achieve the purpose of reducing the injection of water injection wells, so as to slowly improve the construction. pressure. The crack passes through the near-well damage zone of the injection well. Under the action of rock stratum opening and shear slip, artificial short cracks will be formed. Since the artificial short crack has a certain conductivity, it can change the flow of injected fluid around the wellbore. In this way, the damage caused by the water injection process to the reservoir will be greatly relieved, thereby improving the water injection capacity of the main injection well. In fact, the pressure loss near the wellbore is very small, and it is affected by factors such as the difference between the position and the crack in the deep part of the formation. The flow of the fluid has both linear flow and radial flow, and there are mixed flow phenomena in some positions, while linear flow The resistance is lower than the radial flow. Analysis of the bottom hole pressure curve shows that the bottom hole pressure of the injected water injection well is much lower than that of the non-fracturing radial flow, and is lower than the pressure after the acidification treatment, thus changing the formation fluid flow. Regularity, that is, from radial flow to bilinear flow, can achieve water well increase in low permeability reservoirs. Under normal circumstances, the injection wells that are insufficient for water injection and reservoir energy loss caused by near-well pollution are suitable for fracturing technology. The comprehensive situation of injection wells should be fully considered in the selection process, including reservoir connectivity, fault distribution, Reservoir capacity, injection well injection, wellbore integrity, etc., requires good connectivity of the injection well reservoir, clear injection-production relationship, and the fault distance is greater than 100mm, and the cementing quality is excellent, there is no stringing between the layers, etc. .

## 2. The Influencing Factors of Fracturing Technology

The application of fracturing technology in low-permeability reservoir water injection wells, the main influencing factors include the following aspects:

First, the degree of damage to the reservoir by the fracturing fluid. Commonly used fracturing

fluids include clean water, clean fracturing fluid and silicone fracturing fluid. In the actual application process, if the fracturing fluid has too much damage to the core, it will obviously increase the difficulty of water injection, so when selecting the fracturing fluid It is preferred to have a lower damage to the core. Different fracturing fluids also have different degrees of damage to the formation. It is known from the test results that the addition of 2% clay stabilizer in the fresh water fracturing fluid is less harmful to the core than the other two fracturing fluids, and the core damage rate About 10%; the core damage rate of the clearing fracturing fluid is lower than that of the silicone fracturing fluid, but the cost of cleaning the fracturing fluid is significantly higher than that of the fresh water fracturing fluid; the damage of the silicone fracturing fluid to the core is the above The highest of the three fracturing fluids, reaching 50%, the core damage is too high will cause the water injection pressure to rise rapidly, resulting in water injection difficulties, so it is not suitable for low permeability reservoir water injection wells. Comprehensive comparison of the effects of three fracturing fluids, low-permeability reservoir injection wells are usually preferred with clear water fracturing fluids.

Second, reservoir physical properties. The two most important characteristics of reservoir properties are porosity and permeability. The important evaluation index of porosity is rock porosity, which refers to the rock reservoir capacity. The larger the porosity, the better the fluid flow effect. Permeability is an important indicator for evaluating the permeability of reservoirs. It refers to the property of allowing rocks to pass under a certain pressure difference. The higher the permeability, the higher the amount of injection. It can be known from the Darcy formula that the faster the water absorption rate of the reservoir is, the higher the permeability will be. The permeability of the reservoir will directly affect the water absorption intensity of the formation. Therefore, the higher the permeability of the reservoir, the more the water injection volume of the injection well will be. Big.

Finally, the impact of other factors. In addition to the physical properties of the reservoir and the degree of damage to the reservoir by the fracturing fluid, factors such as the wettability of the reservoir rock, the capillary force caused by the wettability, and the driving pressure of the water injection also have an effect on the fracturing technology. The weak hydrophilicity of the reservoir rock is more conducive to water injection fracturing. Because of its wettability, the capillary force is inversely proportional to the wetting contact angle. The larger the contact angle, the smaller the capillary force, and the local layer rock pore radius is lower than 2.5. Mm, the capillary force will increase rapidly, especially for the pore throat of the formation, the pores of the throat are smaller, the corresponding capillary force is larger, and the formation water needs to overcome the larger capillary force to be able to be in the formation with smaller pores. flow. The driving force of water injection at the wellhead is usually large. The pump pressure plus the pressure of the liquid column is the bottom hole pressure. The pressure difference between the well and the original reservoir is large. When the injected water flows from the bottom of the well to the bottom of the oil well, it needs to overcome the flow process. Capillary forces, and to overcome the flow resistance of the crude oil, so it will have a certain impact on the fracturing technology.

### **3. Application Examples of Fracturing Technology for Water Injection Wells in Low Permeability Reservoirs**

#### **3.1 Reservoir Characteristics**

The oil well reservoir in a low permeability area has a buried depth of 2950m and a reservoir temperature of 93-116 degrees. The normal pressure system has its reservoir characteristics mainly reflected in the following aspects: analysis of reservoir permeability, the reservoir is low porosity and low permeability. Sandstone reservoirs have an effective permeability of  $0.16-0.5 \times 10^{-3} \mu\text{m}^2$ , a pore-to-throat radius ratio of 90-240, and an average throat radius of 0.65  $\mu\text{m}$ . Analysis of the rock mechanical properties of the reservoir shows that it is characterized by plastic formation, Young's modulus is 4820-13560 MPa, the formation is soft; the rock has strong stress sensitivity, and the effective stress is increased from 15 MPa to 25 MPa; the minimum principal stress is large. The

average closed stress gradient was 0.0183 MPa/m; the permeability decreased to 10%-1%. Analysis of the reservoir lithology characteristics shows that it is characterized by medium-strong water sensitivity, clay content of 8.5%, montmorillonite content of up to 40%; formation dip angle of up to 35 degrees, due to large dip angle, fracturing Many cracks are easily formed during the construction process, and the frictional resistance of the fracturing fluid during construction is large. The reservoir fluid characteristics are two high, the freezing point is as high as 34.7 degrees, and the wax content is 18.6%.

### **3.2 Fracturing Design of Water Injection Well**

Different from ordinary oil well fracturing, there are many influencing factors of fracturing in water injection wells. Not only the development of well nets will limit the scale of fracturing, but the reservoir characteristics will have a direct impact on the determination of fracturing process parameters and conductivity. The low-permeability reservoirs in this study have complex reservoirs, large dip angles, and large minimum principal stresses. Multiple fractures are easily formed during fracturing, and the estimated frictional resistance of the fracturing fluid during construction is close to 30 MPa, due to the large friction loss. Therefore, the construction difficulty has increased. In view of this situation, it can be solved by increasing the perforation density and reducing the phase angle of the perforation. The amount of the pre-liquid is reduced as much as possible, and the pumping time of the low sand ratio is increased. After the completion of the construction, the flow is returned within 2 hours. The liquid is applied with the base liquid and then the cross-linking agent is used for construction; in addition, the construction parameters are optimized during the construction process to improve the fracturing effect.

### **3.3 Optimization of Fracturing Construction Parameters of Water Injection Wells**

The optimization of fracturing construction parameters of water injection wells mainly includes hydraulic fracture length, construction scale, well return control and fracturing fluid system.

The low-permeability zone reservoir adopts the method of water injection in the anti-seven-point well pattern, the well spacing is 250m, and the direction of the artificial crack is near east-west. To optimize the length of hydraulic cracks, the VIP numerical simulation software of black oil model can be applied, the grid is divided, the artificial cracks are described in detail, and the influence of the length of the injection well on the development of the well group is analyzed. Since the low-permeability zone of the oilfield is relatively close to the fault zone, a variety of complex stresses will affect it. Therefore, the reservoir simulation assumes that the fracture extends along the line of the oil-water well. According to the simulation software analysis results, the oil-free oil recovery period will be shortened with the increase of the water well seam, so the optimal effective support crack length is 40-60m; as mentioned above, the Young's modulus of the reservoir is 4820~13560MPa. The compressive strength is 115 MPa. Not only the reservoir is soft, but also the obvious plastic stratum characteristics, and there is a certain proppant embedded in the reservoir rock. Based on the analysis results, the actual fracturing construction design in the water well fracturing construction joints Controlled at 60-75m.

In order to reduce the injection pressure of the wellhead, it is necessary to form a crack with a certain conductivity in the reservoir. The calculation of fracturing cracks can be simulated using the Fracpro PT Fracture Design Software. According to the software simulation calculation results, the average sand-to-liquid ratio is adjusted to 15%. During the construction process, continuous sanding should be maintained. The sanding gradient should not exceed 90kg/m<sup>3</sup>, and 0.45-0.9mm ceramic proppant should be used. After optimizing the construction scale, the sand addition amount is reduced from 30m<sup>3</sup> to 12m<sup>3</sup>, which greatly improves the fracturing cost and fracturing effect of the low-permeability plastic formation water injection well.

Because the reservoir in the low permeability zone of the reservoir has strong stress sensitivity, such as excessive backflow, it will increase the effective closing stress of the near well. Therefore, it is necessary to strictly control the return of the well, and then transfer to 90% after returning to avoid reservoir permeability. It will be affected by the decline and ensure the effect of fracturing

construction. It is also necessary to do post-pressure management. In the later water injection development, the water quality of the injected water should be strictly monitored to maximize the effective water injection period and avoid the near-well damage caused by water sensitivity and other factors. In addition, the fracturing fluid system needs to be further optimized. As mentioned above, the fracturing fluid will have a direct impact on the fracturing construction of the water injection well. The fracturing fluid not only has better sand-carrying ability, but also fully considers its compatibility with the reservoir. The reservoir clay content in the low permeability zone of the reservoir is relatively large, reaching 8.5%, and the montmorillonite content is as high as 40%. Therefore, the double-clay anti-swelling fracturing fluid system can be used, which inhibits clay expansion, diffusion and migration performance. Good, can effectively prevent clay from swelling.

### **3.4 Construction Effect**

Through the above optimization measures, the fracturing construction scale, liquid volume, sand ratio, displacement, sand amount and other parameters of the injection well in the low permeability zone reservoir can be basically determined, and the reservoir structure is fully considered in combination with the well structure and construction equipment. Other features include strong water sensitivity, narrow throat radius, and strong stress sensitivity. In the actual construction process, multiple layers are simultaneously pressed open, and the problems of poor shielding effect of the partition, ineffective extension of the seam height, and danger of pressing the water layer are avoided. From the analysis results of the back-and-drain liquid after pressurization, it can be known that the viscosity of the return-discharge liquid is close to that of water, and there is no obvious flocculent suspended matter; etc., it is possible to try to directly inject water without pressing back after the crushing fluid is fully broken. It can simplify the construction work, and can ensure the fracturing effect and improve the water absorption capacity of the oil layer.

## **4. Conclusion**

In short, the fracturing technology of low-permeability reservoir water injection wells is an important technical measure. It uses high-pressure pumping group to inject liquid displacement far beyond the absorption capacity of the formation into the well, causing the formation of cracks in the bottom formation, and the liquid with proppant. The crack in the injection joint will gradually extend forward, and a sand-filling crack with considerable length, height and width will be formed in the formation, which can achieve the effect of increasing the injection. In the actual construction process, the damage factors of the fracturing fluid to the reservoir and the physical properties of the reservoir should be fully considered, and the fracturing optimization work should be done according to the actual conditions of the reservoir to achieve better fracturing effect.

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