Analysis of Influencing Factors and Improvement Measures of Water Injection Development Effect in Low Permeability Reservoir

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Abstract. The global oil resources are facing the shortage phenomenon, so the improvement of reservoir production efficiency is a major problem faced by researchers at present. In recent years, low permeability reservoirs have been highly valued by relevant scholars because of their abundant reserves. The production effect of low permeability reservoirs is affected by many factors, including water flooding development potential, effect and artificial control.

Keywords: Low permeability reservoir, Water injection development effect, Factors, Improvement measures.

1. Introduction
With the continuous exploration and development of oil fields in China, the number of low permeability oil fields is increasing. Low-permeability oilfield has the characteristics of relatively low permeability and relatively small single well output, which is widely distributed in China. According to authoritative statistics, more than half of the newly discovered oil and gas fields in China in the past few years are low permeability reservoirs, and the results of China's energy reserves survey show that the production capacity of low permeability oil fields has exceeded 3/4 of the total production capacity of China's oil and gas fields, and the undeveloped low permeability oil fields in China are all over the country. This means that if it can be exploited reasonably, it can obtain a large amount of oil and gas resources, increase production capacity, solve the problem of energy shortage in China, provide more energy for residents, and further promote the upgrading of China's industrial level. However, the low permeability oilfield has certain particularity, and its output is very low. When the oilfield is put into development for a certain period of time, there will be some problems, such as a sharp decline in the quality of crude oil products and an
increase in comprehensive water cut. If the production technology can not be improved and the cost can be reduced, the input-output ratio of low permeability oilfield will be small, which will affect the development and utilization of energy.

3. Water injection development
With the increase of production, the reservoir pressure gradually decreases. In order to ensure sufficient pressure in the reservoir, technicians inject a certain amount of water into the reservoir through professional equipment to supplement the energy of the underlying oilfield, ensure that the oilfield can continue to produce oil smoothly, realize the maximum exploitation of low permeability reservoir resources, and avoid resource waste caused by insufficient reservoir pressure. This is the reservoir water injection process. In the exploitation process of low permeability reservoir, with the continuous increase of exploitation amount, the corresponding reservoir pressure will gradually decrease. When the pressure drops to a certain critical value, the oil field will no longer produce oil, and deoiling will occur, resulting in a significant decline in crude oil production and a sharp decrease in oilfield production efficiency. A large amount of crude oil that can be produced can only be abandoned in the surface layer. In the long run, it will cause waste of resources, which will seriously restrict the development of China's petroleum industry. In order to break the current situation of insufficient pressure in low permeability reservoirs, technicians invented the water injection technology for reservoirs. By injecting water into the reservoir and increasing the reservoir pressure, a large amount of crude oil left in the surface layer can continue to be successfully developed, which improves the production efficiency of the oilfield and increases the development effect of the oilfield. To sum up, reservoir water injection is a valuable and significant technology, which plays an important role in prolonging the development life of oil fields, so it is necessary to intensify the research and development of this technology.

4. Influencing factors of water injection development in low permeability oilfield

4.1. Pore characteristic factors
Pore characteristics will have a serious impact on water injection development. Pore characteristics mainly include three aspects, namely, the throat radius in the formation, the basic shape of pores and the connection between pores. In general, the pore throat radius in the formation of low permeability oilfield is less than 2.48μm, and most of the pore throat radius is maintained at 0.06 ~ 1.1 μm. There are generally stagnant layers in the pores of the formation, the thickness of which is basically the same as the diameter of the pores, both of which are about 0.1 μm. The crude oil in the stagnant layers also belongs to the crude oil in the pores. However, the crude oil in the pores can flow, but the crude oil in the stagnant layer cannot flow. Only by continuously pressurizing the formation can the crude oil flow in the stagnant layer be realized.

4.2. Additional seepage resistance
In rock and soil pores, crude oil can flow only under a certain pressure. The minimum value of the pressure can reflect the resistance of crude oil flowing, enlarge the pore diameter, obviously reduce the resistance and facilitate the flow of crude oil. In low permeability oilfield, rock and soil pores are small and unevenly distributed, so the resistance is generally large, and with the change of pressure gradient, the resistance will also change, and the pressure gradient will increase, which will lead to the flow of crude oil stored in more pores, thus leading to the increase of flow resistance. When the pressure gradient no longer changes, the additional seepage resistance will become a fixed value.

4.3. Factors of permeability change
The soil around the oilfield will bring some pressure to the reservoir, but the influence of the surrounding soil on the reservoir is relatively small. Therefore, the radius of the fluid that starts to flow under the influence of the surrounding soil is relatively small. If the distance between the oil well and the water injection well is relatively long, it is difficult for water injection development to play its due role. At the
same time, if the distance between them is relatively long, the driving pressure will decrease continuously, the permeability of the formation will also decrease, and the seepage capacity of the formation will also decrease. In the process of water injection development in low permeability oilfield, if the water injection rate is relatively high, there will be a problem of water accumulation around the water injection well, and it is difficult to inject the energy of fluid into the production well when a high pressure area is formed around the water injection well. It is very likely that there will be a low pressure area around the production well, which will eventually make the pressure supply around the production well insufficient, and the production efficiency and output of the oil well will be seriously reduced.

5. Measures to improve the development effect of water injection in low permeability reservoirs

5.1. Horizontal well development
At present, in order to effectively improve the effect of water injection development in low permeability reservoirs, new development technologies must be used. Therefore, corresponding technicians and designers need to have a more comprehensive understanding of low permeability reservoirs. According to the research, it can be found that the development of horizontal wells can effectively improve the effect of water injection development in low permeability reservoirs, and there are relatively few deficiencies in the actual use process. Especially in the process of area control of a single well, technicians need to ensure that they can cut the sand body in the river channel accordingly. Only in this way can the low single layer be penetrated, thus minimizing the influence of river cutting on water injection effect. In the actual development process, if the pressure is too high, it will not only affect the liquid flow process, but also make the control of the whole well more difficult. Therefore, the water pressure can be effectively controlled by using a scientific and reasonable horizontal well development method, thus ensuring that the actual pressure difference can be improved by adjusting the flowing pressure at the bottom of the well. Compared with the traditional development method, the horizontal well development method has a better development effect, so in the later stage, the staff can give priority to the horizontal well development method when developing low permeability reservoirs with water injection.

5.2. Adopt efficient perforating technical measures
In the development of low permeability reservoirs, high-efficiency perforation technology measures are used to increase the exposed area of oil reservoirs. In the process of water injection development, in order to increase the affected area of water injection, it is necessary to connect water drive, replenish energy for oil flow in real time, and continuously improve the output of oil wells. High-energy perforating technology is used to increase the effect of hydraulic fracturing, further strengthen the perforation strength and density, and lay a good foundation for flowing into wells in low permeability reservoirs.

5.3. Expand the flow radius and reduce the difficult flow zone
Compared with ordinary oilfields, the number of oil-bearing formations in low permeability reservoirs is less. If blindly trying to improve the permeability of rock and soil, it will lead to conflicts among oil-bearing formations. Therefore, in water injection, the layered water injection method should be adopted, supplemented by fracturing reconstruction, so as to increase the easy flowing radius of the formation, make the injected water fully penetrate into the oil-bearing layer and play its role, and improve the oilfield production. In addition, the distance between water injection well and production well should be shortened as far as possible in planning and construction, so as to reduce the difficult flow zone and give full play to the role of water displacement mechanism, so as to increase the pressure difference between them and make the crude oil more easily exploited. However, blindly shortening the distance between the two will lead to a substantial increase in the number of wells required in the project and the production cost. Therefore, in actual production, it is necessary to consider the field situation,
comprehensively analyze a number of parameters, and reasonably determine and plan the well spacing and well number.

5.4. Application of early water injection mode
The natural fractures in low permeability reservoirs are relatively small, and the elastic energy is insufficient, so they cannot meet the production standards of oil fields. Therefore, before the oilfield is not exploited, it is necessary to inject water into the corresponding parts of the oil layer, and store energy in the low permeability reservoir, thus laying a foundation for the later oilfield exploitation. At the initial stage of the oilfield, it is necessary to design the way and scheme of water injection, and then investigate the field production site, and use scientific and reasonable means to ensure the development of low permeability oilfield with reliable technical support.

5.5. Combined injection and production of single sand body
In the actual development process, although the low permeability reservoir belongs to a whole structure, in order to improve the effect of water injection development, the low permeability reservoir should be divided into different basic units. Therefore, in the actual operation process, different basic units and operating units must be clearly defined. Its operating unit is mainly a small layer, while its basic unit is mainly a single sand body, and it can effectively combine the operating unit with the basic unit, so that the single sand body can be injected and produced together. In this way, not only the production intensity can be improved vertically, but also the overall development efficiency of low permeability reservoirs can be improved.

6. Conclusions
Low permeability reservoirs are abundant in China, accounting for half of fossil energy. At present, water injection mining technology is the lowest cost and highest efficiency mining method. It is an urgent problem to deeply analyze the production characteristics and influencing factors of water injection technology and improve and upgrade it on the existing basis. It can effectively alleviate the shortage of resources in China, reasonably reduce the exploitation cost, improve oil recovery, increase economic benefits, bring opportunities for oil and gas exploitation in China, and further promote the development of China's industry and economic progress.

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