Development Characteristics and Development Technology Analysis of Low Permeability Oilfield

Nan Zhang1,*
1Qingxin Oilfield Development Co., Ltd., China, 163458
*Corresponding author e-mail: qxzn@petrochina.com.cn

Abstract. Oil is an important energy resource in the world. Therefore, the oil extraction efficiency will affect the social and economic development of our country, which requires us to constantly improve our own extraction technology and improve the efficiency of oil development. Although China is a country with abundant oil reserves, most of the oilfields in China are low permeability ones. There are many problems in Low permeability oilfield (hereinafter referred to as LPO), such as small porosity, low permeability, difficult production and so on. Therefore, this paper first analyzes the characteristics of LPO, such as low natural productivity, poor water absorption capacity, rapid decline after fracturing. Therefore, China has made more research on LPO, which has formed a relatively complete series of LPO production technology. Finally, this paper summarizes the current development technology of LPO in China, which will realize the economic and effective development of LPO.

Keywords: Low Permeability Oilfield, Development Technology

1. Introduction
With the continuous development of the oilfield, the water content of the old oil field will increase year by year, which will increase the difficulty of oil exploitation. At the same time, most of China's low permeability reservoirs have become an important guarantee for oil production. By the end of 2006, the proven geological reserves of Low-permeability Oilfields in China are about 9 billion tons, accounting for 45% of the national oil reserves. The reserves of ultra-low-permeability reservoirs are about 5.5 billion tons, accounting for 61% of the reserves of low-permeability reservoirs. However, there are still many problems in the exploitation of LPOs, such as high difficulty and high cost[1].

With the deepening of oilfield development in China, the development of low permeability oil and gas fields is facing unprecedented challenges, which are mainly divided into three aspects. First, the development effect of developed oil and gas fields is getting worse. With the increase of water cut, the decline of oil production is accelerated. Second, the grade of undeveloped reserves is getting lower and lower, which is mainly concentrated in ultra-low abundance and ultra-low permeability reservoirs. Therefore, it is more and more difficult to optimize blocks and waterflooding development. Third, the development potential and effective measures are gradually reduced. With the increase of cost, the contradiction between input and output is increasing. By providing technical support, we can promote the continuous development of low permeability reservoirs[2].
2. Study on characteristics of LPO

2.1. Geological features

LPO is a kind of oil field with complex vertical and horizontal oil-water distribution, which will often appear in oil wells. Therefore, the oil-water phenomenon increases the difficulty of well layout and oilfield development. Generally speaking, the scale of reservoir sand body in LPO is relatively small, which will affect the control effect of water drive in oilfield development well pattern. The main target layer of oil-water development is rich reservoir, which belongs to low permeability reservoir with permeability of about $10 \times 10^{-5}$um$^2$ and porosity of about 15%. The physical properties of low permeability reservoirs are not ideal, which leads to low natural productivity of oil wells. Therefore, LPO must be fractured to produce oil[3]. In the actual development, about 35% of the water injection wells have a daily water injection volume of less than 5m$^3$, and a quarter of the wells can’t guarantee the estimated oil storage. Therefore, the mining time of many natural energy is more than half a year. As the formation pressure decreases, the well production also decreases. When injecting water into the oilfield area, the water cut of 30% oil wells will rise in a short time, which will lead to production decline. At the same time, 60% of oil wells have poor water injection effect, which will further affect the production.

2.2. Physical characteristics

Heterogeneity and pore structure are the physical characteristics of LPO. In general, the recovery effect of heterogeneous oilfield is poor. At the same time, there are obvious differences in the vertical and horizontal physical characteristics of mining, and the indexes of lithology and thickness are unstable. Once the lithofacies changes, the lithology thickness and pay layer thickness are more unstable, which will lead to the incompatibility of well tips. The porosity of LPO with pore structure has a wide range of variation, usually ranging from 5% to 30%. The average porosity of LPOs abroad is 10.42%, while that of China is 11.5%[6]. According to the division of porosity, LPOs can be divided into high porosity and low porosity. High porosity oilfields contain siltstone and very fine sandstone with shallow buried depth but large porosity. Low porosity oilfields are mainly concentrated in the reservoir, and the porosity is generally large under the formation of micro dissolved pores.

3. Development characteristics of LPO

Low permeability reservoirs have the characteristics of small porosity, low permeability and deep buried depth, which will lead to low formation pressure. Therefore, low permeability reservoirs do not have natural productivity, and exploration and development are difficult and heavy tasks. The development characteristics of LPO are shown in Figure 1.

![Figure 1. The development characteristics of LPO](image)

3.1. Low initial formation pressure

The formation pressure coefficient of LPO is less than 1 in most cases. Therefore, LPOs have no natural productivity and lack of energy. We usually use dissolved gas to drive oil. However, dissolved gas flooding can easily cause gas to escape to the pores of the formation, which will lead to a rapid drop in gas drive pressure. Therefore, the first oil recovery rate is very low, accounting for about 15% of the total oil content. At the same time, the low initial formation pressure will lead to the obvious decline rate of productivity effect[3].

3.2. Large span of pressure gradient in fluid seepage
When oil and gas flow in the pores of low permeability reservoirs, there is an obvious threshold of starting pressure. When the displacement pressure of oil and gas is greater than the start-up pressure, oil and gas can flow through the pores, and the seepage law shows the characteristics of atypical Darcy flow, which will increase the difficulty of production.

3.3. Cracks have great influence
Fractures have obvious influence on waterflooding development. Therefore, by making artificial fractures, we can enhance the water absorption capacity of water injection wells. At the same time, by increasing the lateral heterogeneity of the reservoir, water is easy to migrate along the direction of fractures, which will lead to water flooding of low-permeability reservoirs. Therefore, when we decide to use water flooding, we must reasonably deploy water injection well network, which is the key process in the development of LPO.

3.4. Strong mineral water absorption capacity
In low permeability reservoir, the content of water sensitive minerals is less than that of reservoir impurities. Therefore, in the process of water injection development, the water absorption capacity of reservoir increases with the decrease of starting pressure of water injection well. The lower the starting pressure, the stronger the water absorption capacity\(^6\).

3.5. Good pressure sensitivity
Low permeability reservoir is very sensitive to pressure. The higher the pressure, the lower the reservoir permeability. At the same time, higher pressure will lead to irreversible permeability. The stronger the sensitivity of low permeability reservoir is, the faster the rate of permeability decline is, the greater the development is.

4. Water injection development technology in LPO

4.1. Advanced water injection
Through the reservoir characteristics of low permeability reservoir, we can establish the geological mathematical model of starting pressure gradient and non-Darcy flow principle in low permeability reservoir. According to the model design, we can reasonably increase the formation energy. By using advanced water injection technology, we can reduce the start-up pressure gradient, which will improve the productivity and production of a single well. The influence of advanced water injection technology on formation pressure is shown in Figure 2.

![Figure 2. The influence of advanced water injection technology on formation pressure](image)

4.2. Method of adjusting well pattern
Well pattern water drive control is often associated with oilfield development. Well pattern waterflooding is the energy basis of synchronous water injection. Therefore, we usually connect the
ratio of sand body distribution area, well spacing and injection production ratio, which requires timely adjustment of well pattern water drive control size. In this way, we can ensure that its standardization and rationality meet the standard, which will ensure the degree of well pattern water drive control. Long term practice shows that the injection production well spacing is closely related to the degree of water drive control. Therefore, the staff should control the well pattern well number, which will improve the production efficiency of LPO.

4.3. Early separate layer water injection method
The number of oil layers in LPO is limited, and the permeability between layers is also different. There are prominent interlayer problems in oil production and water absorption of oil-water wells. Therefore, we must carry out reasonable separate layer water injection in the early stage, which will ensure the development of LPO reserves and reduce the water cut rate. We need to put in new injection wells in the early stage of separate layer synchronous water injection. Therefore, the staff should combine injection and production to separate layers, which will improve the production efficiency of LPO.

4.4. Refracturing Technology
The effectiveness of conventional refracturing method to expand old fractures is relatively poor. Therefore, we must carry out the improvement of refracturing technology for plugging old fractures and pressing new fractures, which will improve the detection of fractures. The first is the technology of plugging old and pressing new ones, which is a method of replacing some plugging agents with special materials. By injecting the plugging agent into the specified position, we can seal the fracture and perforation scientifically and reasonably. At the same time, we can't get into the pores of the formation and plug the pores of the rocks. Second, through directional perforation technology, we can carry out a second refracturing, which can change the direction of fractures. Third, refracturing and perforating are carried out in the producing layer, which will produce crude oil near the minimum principal stress. At the same time, we can control the amount of water injected, which will increase oil production.

5. Conclusion
Under the background of China's increasing oil demand, more and more people pay attention to China's oil exploitation, which puts forward higher requirements for oil exploitation. Therefore, the staff should ensure the advanced nature of application technology. By giving full play to oilfield development technology, we can better exploit LPO, which can comprehensively improve oil recovery rate.

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