

# Research and Practice of CO<sub>2</sub> Flooding Technology in Ultra-low Permeability Reservoir of XX Oilfield

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**Abstract.** CO<sub>2</sub> flooding technology in ultra-low permeability reservoir is the key technology in modern oilfield technology development, which plays a key role in oilfield exploitation of ultra-low permeability reservoir. In this paper, CO<sub>2</sub> flooding technology for ultra-low permeability reservoir in oilfield is analyzed and studied. The main characteristics of ultra-low permeability reservoir in oilfield are briefly analyzed, and the development of CO<sub>2</sub> flooding technology is discussed. At the same time, the application of CO<sub>2</sub> flooding technology in ultra-low permeability reservoir of XX Oilfield is studied and summarized.

**Keywords:** Oil field, Ultra-low permeability, Oil reservoir, CO<sub>2</sub> flooding technology.

## 1 Introduction

Oil is an important resource used in the development of modern society, and it has a good application in many fields of social production. However, oil resources are non renewable resources. The increasing demand for modern oil resources leads to the depletion of oil reserves in the modern world. And the exploitation of oil resources has also entered a more difficult stage. The development of low and medium permeability reservoirs in oil fields is difficult, which has become an urgent problem to be solved in modern oil field exploitation. In the research process of modern oilfield exploitation technology, relevant experts put forward that CO<sub>2</sub> flooding technology can improve the development efficiency of ultra-low permeability reservoirs and play a vital role in the comprehensive exploitation of modern petroleum resources.

## 2 Brief analysis of ultra-low permeability oil reservoir in oilfield

Ultra-low permeability reservoir specifically refers to the ultra-low permeability oil and gas fields encountered in the process of oilfield development in China, which is an important part of oilfield development in China. Ultra-low permeability reservoir has the following characteristics.

First of all, the ultra-low permeability oil field has the characteristics of high reserves. Because of its relatively difficult oil field exploitation, the exploitation and development efficiency of low permeability oil field is relatively low, and its own oil field reserves are relatively large. According to relevant data, the reserves of ultra-low permeability reservoirs account for more than 1 / 3 of the

development reserves of undeveloped oilfields in China, and the reserves of low permeability layers account for about 50% of the total discovered reserves. In the future, low permeability reservoir will be an important working area of oil resources in China.

Secondly, the development of low permeability reservoir has the characteristics of low permeability. According to the relevant data, the development permeability of low permeability reservoir is 0.3 ~ 10 mD, and the oil and gas permeability of the oilfield is relatively small, which affects the actual oilfield development efficiency. In addition, in the current process of oilfield exploitation in my country, the exploitation depth of oilfields with ultra-low permeability de-reservoir is above 3000m, which causes exploitation difficulties.

At present, ultra-low permeability oil reservoirs are the key target of my country's oilfield development. The reasonable exploitation of oilfields in low permeability reservoirs is conducive to the exploitation of my country's petroleum resources. In the actual process of oil resource exploitation, CO<sub>2</sub> flooding can improve the development efficiency of ultra-low permeability reservoirs, ensure more effective oil field development and maximize the oil field exploitation effect.

## 3 Principle analysis of CO<sub>2</sub> flooding technology

Now all countries in the world are studying the CO<sub>2</sub> flooding technology of ultra-low permeability reservoirs. For example, after the SACROC block of Snyder Oilfield in the United States is put into production, CO<sub>2</sub> flooding technology can be adopted. Its principle is mainly to improve the fluidity of crude oil by using CO<sub>2</sub>. After the

application of CO<sub>2</sub> method, the volume of crude oil will expand, so as to realize the oil-gas mixing, and finally realize the good development of the oil field, and finally ensure the better oil-gas development effect.

The CO<sub>2</sub> flooding technology in SACROC block of Snyder Oilfield in the United States mentioned above is the earliest CO<sub>2</sub> flooding technology applied for patent. In the process of oil exploitation technology research in our country, many oilfields have also started the research of CO<sub>2</sub> flooding technology. In the research of oil displacement technology, CO<sub>2</sub> is used as oil displacement agent to improve the fluidity of oil in local reservoirs, so as to realize the convenient control of oil exploitation, and also to maximize the efficiency of oil exploitation. In the research of modern CO<sub>2</sub> oil displacement technology and methods in China, there are still some problems in the current oil displacement technology. In the research of oil displacement technology, it is found that the technology of ultra-low permeability reservoir still has some problems, such as high miscibility pressure, difficult miscibility and low oil displacement efficiency. Therefore, in the research of modern oil production technology in China, we should pay more attention to the improvement of production technology, Ensure more active and rational oil exploitation and improve oil exploitation efficiency.

## 4 Research and analysis of CO<sub>2</sub> flooding technology in XX Oilfield

### 4.1 Expounding of CO<sub>2</sub> flooding technology in XX oilfield

XX oil field is an important oil field in my country. In its oilfield development technology research, CO<sub>2</sub> flooding technology research is an important technology in the region, which plays a key role in oilfield development. In the technical exploitation of the XX oilfield, certain improvements have been made to the CO<sub>2</sub> flooding technology currently used in my country. The miscibility of this technology has reached  $\geq 1$ , permeability  $> 0.5$  mD, formation crude oil viscosity  $< 12$  mPa·s, formation crude oil density  $< 0.876$  g/cm<sup>3</sup>, and oil layer depth  $> 2000$ . At the same time, in the application of this technology, the lower limit of the physical properties of CO<sub>2</sub> flooding in the reservoir is considered. When the reservoir permeability is too low ( $< 0.5$  mD), the starting pressure of CO<sub>2</sub> flooding will increase significantly, and it is difficult to achieve effective displacement under conventional pressure difference.

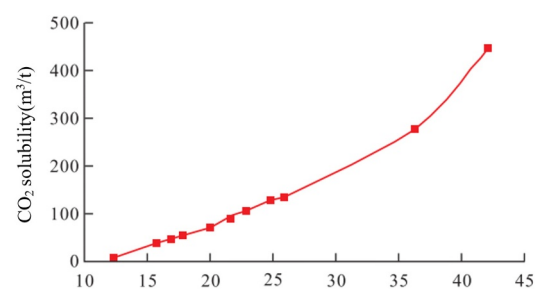
### 4.2 Evaluation of CO<sub>2</sub> flooding technology in XX Oilfield

In this research process, the application of CO<sub>2</sub> flooding technology in ultra-low permeability reservoir of XX Oilfield is studied. The laboratory test and evaluation standards are established, aiming at the extraction function, phase characteristics, miscible pressure test and oil displacement efficiency of CO<sub>2</sub> flooding technology

in ultra-low permeability reservoirs. The following is a summary of the specific experimental research.

#### (1) Analysis of phase characteristics of CO<sub>2</sub> flooding technology

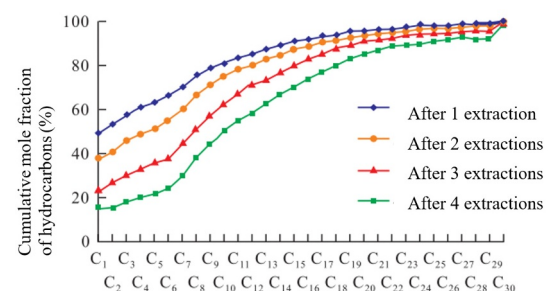
During the phase characteristics research, No.1 well in XX Oilfield was selected for experimental analysis. In the process of analysis, the PVT analyzer with high temperature and high pressure was used for experimental research, and it was found that there was a certain relationship between CO<sub>2</sub> solubility and pressure in the formation. The greater the pressure, the greater the solubility. The results show that formation crude oil has a strong solubility for CO<sub>2</sub>, and the higher the pressure, the greater the solubility of CO<sub>2</sub> in crude oil. As shown in Figure 1.



**Figure 1** Curve relationship between CO<sub>2</sub> solubility and pressure

#### (2) Analysis of CO<sub>2</sub> crude oil extraction

The main principle of oil displacement by CO<sub>2</sub> is to analyze the extraction of crude oil by CO<sub>2</sub>. In the process of local test analysis, PVT instrument is also used for actual analysis. In the process of instrumental analysis, carbon dioxide has a good extraction effect on hydrocarbons in petroleum. Hydrocarbon is the light component of petroleum resources, and the oil in reservoir with reduced permeability of light components is closer to the oil in stratigraphic oil field, thus facilitating the effective development of petroleum resources. Through the good development of oil resources, ensure its rational application. Moreover, the extraction of carbon dioxide can also realize the dynamic miscible state of crude oil, thus facilitating the exploitation of crude oil. Figure 2 shows the change of pure hydrocarbon components in equilibrium liquid phase.



**Figure 2** Changes of pure hydrocarbon components in the equilibrium liquid phase

(3) Analysis of the minimum miscible pressure of CO<sub>2</sub> and crude oil

The minimum miscible pressure of CO<sub>2</sub> and crude oil is a very key link in oil displacement technology, which is very key to the reasonable determination of modern oil displacement parameters. At the same time, in the process of technical research, relevant experts proposed to use the thin tube test method to carry out the minimum miscible pressure test. In the research, the minimum miscible pressure of six oilfields in XX Oilfield is studied. The data research shows that the average miscible pressure of six oilfields can reach about 30MPa. Compared with CO<sub>2</sub> flooding technology abroad in the same period, the miscible pressure is generally below 12MPa. Foreign oilfields have high content of light components, relatively low viscosity and density, which is convenient for exploitation. Therefore, in the actual research of oilfield technology, China's oilfield exploitation should pay attention to the effective control of the minimum miscible pressure of crude oil to improve the oilfield exploitation effect.

(4) Study on CO<sub>2</sub> oil displacement efficiency

In the research process of this paper, it is very important to study the oil displacement efficiency of the position. To a certain extent, it is related to the working effect of oil displacement efficiency, ensuring that the application of oil displacement efficiency is more reasonable, and also improving the oil displacement effect to the greatest extent. In the study of oil displacement efficiency, this paper designed a physical simulation device, mainly aiming at the water displacement efficiency and CO<sub>2</sub> displacement line.

①At first, the oil displacement efficiency of water flooding is 33%, and then the oil displacement efficiency of CO<sub>2</sub> miscible flooding is 85%.

②Secondly, in the test, the oil displacement efficiency of the water flooding method after the direct CO<sub>2</sub> miscible flooding method can reach 80%.

③In the process of oil displacement efficiency analysis, CO<sub>2</sub> oil displacement and water oil displacement are directly mixed for oil displacement, and the oil displacement efficiency can reach 81%.

④In the process of analysis of oil displacement efficiency, direct water flooding is used for oil displacement, and its oil displacement efficiency is about 47%.

Through the study of the above analysis methods, it can be found that the oil displacement method using CO<sub>2</sub> and water flooding has the highest efficiency, which can reach more than 81%.

(5) Influence of produced steam reinjection on CO<sub>2</sub> flooding

In the process of CO<sub>2</sub> oil displacement, CO<sub>2</sub> gas will also be produced in the process of oil displacement. In the actual research, it is found that the increase of carbon dioxide content also has a certain influence on the oil displacement efficiency. Therefore, during the experiment in this paper, the influence of carbon dioxide on oil displacement efficiency is analyzed. Fig. 3 shows the influence analysis of carbon dioxide content on oil displacement efficiency. Through analysis, it can be

found that the higher the carbon dioxide content, the higher the oil displacement efficiency. The carbon dioxide content reaches 100%, and the oil displacement efficiency can reach more than 80%.

Through the above-mentioned experimental research, it is found that in the research of CO<sub>2</sub> flooding oilfield ultra-low permeability reservoir technology, the higher the CO<sub>2</sub> content, the better the oil displacement efficiency. At the same time, the combined flooding of water flooding and CO<sub>2</sub> flooding has higher oil displacement efficiency. The carbon dioxide has a good extraction effect on the pure hydrocarbon components in petroleum, and can also improve a good oil displacement effect.

## 5 Summary of key points of CO<sub>2</sub> flooding technology in ultra-low permeability reservoir of XX Oilfield

The above research shows that the oil displacement technology of ultra-low permeability reservoir in XX Oilfield has good oil displacement effect. The following is a summary of the key points of oil displacement technology in its oilfield. To ensure more reasonable oil displacement in the oilfield, the following is a detailed technical summary and analysis.

(1) CO<sub>2</sub> Huff and Puff Selection Well

CO<sub>2</sub> huff and puff well method in ultra-low permeability reservoir can effectively improve the development efficiency of ultra-low permeability reservoir, and in the actual oilfield exploitation process, we should pay attention to adopting necessary well selection principles.

①According to the relevant data, when the porosity reaches 10-20%, the reservoir reserves reach the highest value, but the effect of CO<sub>2</sub> huff and puff in the well is relatively low. The main reason is that the porosity of 10-20% is too large, which leads to the low efficiency of carrying residual oil during CO<sub>2</sub> spit-out, which affects the actual reservoir exploitation.

②Reservoir pressure is also one of the important indexes affecting well selection for CO<sub>2</sub> huff and puff. It also plays a very important role in oilfield development. In actual research, the reservoir pressure of CO<sub>2</sub> huff and puff well selection is divided into less than 10MPa, 10-15 Mpa, 15-20 Mpa, 20-25 Mpa and greater than 25 Mpa. However, it is found that when the reservoir pressure is 10-25 Mpa, the CO<sub>2</sub> huff and puff recovery effect is the best, and the oilfield development efficiency is relatively high.

③In the process of oil exploitation, relevant research shows that the CO<sub>2</sub> huff and puff well selection effect is better when the water content is 50%, which plays a very important role in oil exploitation in low permeability reservoirs [1].

(2) Optimization of injection mode

In the application process of CO<sub>2</sub> oil displacement technology, it also includes a good design of its oil displacement technology to ensure that the oil displacement work is more reasonable. At the same time, in the process of oil displacement, it is required to

optimize the injection mode. At present, in the process of oil exploitation in CO<sub>2</sub> low permeability reservoir, single-line development, continuous water injection, continuous gas injection and gas-water alternate injection are mainly selected for oil exploitation. In the course of this study, the injection modes of different oil fields are analyzed, and the above four different injection modes are mainly established during the test. In the analysis of injection mode, the single elastic development injection mode is adopted. The oil recovery efficiency is 9%, the oil recovery efficiency of continuous water injection mode is more than 17%, the oil recovery mode of continuous gas injection is 27%, and the oil recovery of steam water alternation can reach about 30%. Through the comparative analysis of test data, it is found that using the method of gas water alternation for recovery control can maximize the recovery effect and ensure that the implementation of oil recovery is more reasonable [2].

(3) Optimization analysis of injection production parameters

In the application of CO<sub>2</sub> flooding technology, the design of injection production parameters is very key, especially the control of injection production speed is directly related to the injection production efficiency. Therefore, in the research in this paper, the above test is also used to analyze the injection production rate of CO<sub>2</sub> flooding technology in an oil field. In the course of the test, the test comparison was mainly carried out for the injection-production speeds of 15t/d, 20t/d, 25t/d, and 30t/d. Through the comparison of the test results, it is found that in the actual test analysis process, the gas injection rate is 20t/d, the oilfield recovery efficiency can reach 32.5%, and the injection-production efficiency of 15 t/d is Only about 30%. Therefore, during the implementation of the petroleum gas injection process, attention should also be paid to the control of the gas injection rate, which requires a gas injection rate of 20t/d [3].

(4) Application of injection-production structure

In the application of CO<sub>2</sub> flooding technology, the effective design of the surface injection-production structure is not included. Through the rational design and application of the injection-production structure, the injection-production effect is ensured to be better. In the whole oilfield exploitation process, the application of CO<sub>2</sub> flooding technology mainly includes hydraulic anchor, backwashing valve, tie-back barrel, packing device, multifunctional main steam valve, main steam layer device and so on. By well controlling the injection-production process, the application of oil production technology can be ensured to be more reasonable, and the oil injection-production effect can be improved to the greatest extent [4].

In addition, in this research process of mining technology, in order to improve the application effect of CO<sub>2</sub> flooding technology, the optimization of oil production string has been completed in the actual technical application. Multi-functional oil production string is used for design. In the process of comprehensive design of the project, the optimized design of oil production string is used to improve the oil production effect. In addition, in the oil production process of XX

oilfield, we should also pay attention to the effective control of pipeline corrosion and prevent pipeline corrosion, so as to improve the oil production effect and prevent the impact of corrosive substances on carbon dioxide. In this paper, an economical and reliable anti-corrosion scheme of carbon steel + anti-corrosion coating and FRP is optimized, and a modified imidazoline composite high-efficiency corrosion inhibitor is designed and synthesized. Through the rational use of this preservative, the anti-corrosion effect is optimized [5].

## 6 Conclusions

In this paper, the author analyzes and studies the CO<sub>2</sub> flooding technology of oilfield ultra-low permeability reservoirs. The article summarizes the key points of the application of the technology, and also summarizes the main influencing factors of the CO<sub>2</sub> flooding technology. It is hoped that it will be helpful to the application of CO<sub>2</sub> flooding technology in ultra-low permeability reservoirs.

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