# Technical countermeasure of polymer flooding in oil field

Yi Cheng

Follow-up Water Flooding Room, Institute of Geology, No.6 Oil Production Plant, Daqing Oilfield Company Limited Heilongjiang Daqing 163712 China

**Abstract.** China's economy is in an important period of rapid development, the rapid rise of various industries to produce a greater demand for oil, oil exploitation industry has become the focus of the whole society. The vast majority of oil fields in China have entered the polymer flooding development stage, and the oil reservoir exploitation has been effectively improved. The subsequent water flooding can make the oil reservoir further excavated, which is the key technology of China's oil exploitation industry in recent years. This paper carries out a detailed analysis of polymer flooding follow-up water flooding technology in oilfield, aiming to provide technical help for many oil mining enterprises in China and promote the healthy development of domestic economy.

**Key words:** Oilfield polymer; Drive technology; Water flooding technology.

## 1. Petroleum is an important resource to maintain industrial

production and people's life, especially for China, a country with rapid industrial development, and an important tool to support steady economic development. Although polymer flooding is used in many oilfields in China to obtain higher crude oil recovery rate, the distribution of residual oil in oilfields is uneven, and more effective technology is needed to extract residual oil. Polymer flooding follow-up water flooding is a commonly used mining technology in the world, so it is necessary to conduct systematic research on it.

## 2. Basic information of oilfield geology

The polymer injection test area of an oil field has 1087× [10] ^4t oil storage, formation pressure of 20.1MPa, porosity of 28%, permeability of 7.7 [μm] ^2, calcium content of 228mg/L, magnesium content of 8mg/L, water type, reservoir temperature up to 80℃, belonging to high temperature and high salt reservoir. Since 2013, the oilfield has carried out a water flooding blank test in the polymer injection test area, and polymer injection was formally carried out two months later. The polymer injection test was completed in 2015, officially entering the follow-up water flooding period. A total of 363.58mg/L•PV polymer was injected into the polymer injection test area, a total of 0.25PV gap volume was injected, and 7007T of dry powder was consumed. By 2022, the amount of oil produced in the polymer injection test area has increased to 50.98× [10] ^4t, the oil production rate has increased by 4.66%, and the water content of the oilfield has decreased from 95.03% in the initial polymer injection stage to 78.17%, a decrease of 17.74%. Through the polymer injection test, the goal of oil production with precipitation has been achieved.

## 3. Turn to the optimal period of subsequent water flooding

There was some difference of plane because oilfield polymer flooding effect, and the subsequent water flooding, refer to the moisture content of various speed will have larger to mark, so want to polymer flooding test smoothly into subsequent water flooding, is not recommended as a whole into the way, the best solution should be partial to, so as to avoid low moisture content of oil Wells in polymer, rapid breakthrough in turn subsequent water flooding into the state, To effectively control the increase of water cut in oil Wells [1]. Through research and relative permeability curve of water flooding, can be found if the well when the moisture content is low, the exploitation of the same amount of oil, water flooding water cut increase is far more than polymer flooding water cut increase, but the moisture content increased gap change, as the oil well water cut increase and presented down trend.

In Wells with water cut over 93%, the increase in water cut can be effectively reduced in both waterflooding and polymer flooding. Therefore, when the water cut of the well exceeds 93%, it can choose to switch to subsequent water flooding as a whole. In order to study the increase of water content of oil Wells in polymer injection and subsequent water flooding, and analyze the key factors affecting the subsequent water flooding period of polymer flooding, this paper sorted out a large number of water content change data of oil Wells in subsequent water flooding, and obtained the following conclusions. If the water content of oil well is the same and the amount of polymer is different, there is little difference in the increase rate of water content of water flooding after oil well transfer [2]. If the water cut of oil well is small, the increase of water cut of oil well can also be effectively controlled when it is transferred to subsequent water flooding. The difference of water cut increase between polymer injection and water flooding is mainly affected by water cut of oil Wells. Therefore, it is not recommended that the polymer injection pilot area of this oilfield be directly transferred to subsequent water flooding. It is recommended that after a detailed analysis of the real changes in water content of each oil well, a reasonable design of subsequent water flooding scheme be transferred to control the substantial changes in water content of the oil well by transferring them in batches.

## 4. Application countermeasure of polymer flooding technology in oil field

### 4.1 Profile

Because of reservoir in plane, vertical heterogeneity characteristics, will be affected by subsequent water flooding, lead to the application of polymer flooding residual polymer solution, will go well at the bottom of the big hole, and at the bottom of the high permeable zone quick dash, result in some Wells of mining reservoir contains too many polymers, do not accord with standard of oil application, high cost of separation of polymer, leading to shut-in. Polymer solutions were detected in Wells throughout the polymer injection zone, with concentrations up to 1000mg/L. And subsequent water flooding period during polymer injection, oil Wells of high polymer concentration, polymer can not prove that stranded in a formation for a long time, the polymer will affect the subsequent water flooding extent, result in polymer flooding is difficult to play an ideal oil displacement effect in oil Wells, will inject fluid along the bottom of the macroscopic throats or invalid loop in formation in the high permeable zone. Therefore, it is necessary to do effective profile control in the polymer injection zone and plug the large pores in the oil well and the high permeability layer at the bottom. In general, the higher the permeability and water absorption intensity of the injection well, the more likely there is a high permeability layer in the oil well. Therefore, such Wells are regarded as the primary profile control object [3]. At the same time, attention should be paid to the polymer concentration of the injection well. The higher the polymer concentration of the reservoir, the more profile control is needed. Therefore, for profile control Wells in polymer injection test area, permeability, water absorption strength, polymer production concentration and other factors are taken as standards, and oil well information in polymer injection test area is referred to to select appropriate profile control Wells. After strict selection and deep profile control for 13 oil Wells, it is found that the water absorption index of most of the profile control oil decreases, and the water absorption profile of all the profile control Wells also improves. For example, before profile control in an oil well, the water absorption of 3^4 layer was 3.97%. After profile control treatment, the water absorption of layer 3^4 rises to 32.4%. It can be considered that after profile control operation, the original layer with poor water absorption capacity can effectively improve water absorption, and the water absorption profile can be greatly improved. So far, the total oil increase in profile control area has reached $1.212 \times 10^4$t.

### 4.2 Reperforating layer

Before polymer injection flooding was used in the polymer injection test area, the water injection development mode was mainly used for a long time, leading to the formation of high permeability channels between injection Wells and oil Wells. As a result, water injection will rush forward quickly along the ultra-high permeability layer. Therefore, the application of profile control and water plugging during water flooding and polymer flooding can control the injection of water into most oil Wells, but there are still a few oil Wells with invalid loss of water injection. Therefore, the method of hole filling and layer changing is now applied to seal the extra-high permeability layer and add new horizons by hole filling to realize efficient oil exploitation. After adding holes and changing layers in the polymer injection test area, effective oil increase and precipitation can be realized.

### 4.3 The second polymer injection

The oilfield studied in this paper has the characteristics of high temperature and high salt, so the polymers on the market are screened effectively. Mo-4000 polymer produced in Japan and KYPAM polymer produced in China are proposed to be adopted. The performance indexes of these two polymers exceed the similar polymer products on the market and meet the demand of oil exploitation in the polymer injection test area. Although KYPAM was stronger than MO-4000 in many performance indexes, mo-4000 polymer products were applied in a polymer injection test area, resulting in more mo-4000 polymer residues in the deep bottom layer. In order to make the remaining polymer get effective application, mo-4000 is selected as the oil displacement agent. In terms of polymer dosage, through systematic theoretical research and practical production data analysis, the increase of polymer dosage can obtain greater oil recovery. However, there are limits to how much polymer can be used. Once a certain level is reached, there is a significant decrease in polymer stimulation. Therefore, when using polymer products, it is necessary to pay attention to two factors: recovery improvement rate and polymer oil increase. Combined with well data, a mathematical model was used to simulate the amount of polymer used to find the peak value of both the amount of polymer used and the recovery factor. It is recommended to use 430mg/L•PV polymer to achieve the best oil recovery factor. Numerical simulation of polymer concentration shows that polymer concentration has no significant effect on oil displacement. Increasing polymer concentration only slightly improves oil recovery. Injecting high concentration polymer into oil well will have a great influence on the water content of oil well. The higher the polymer concentration is, the greater the decrease of water cut in oil Wells will be, and the decrease rate will also be improved [4]. Because polymer injection test area has been done before, the optimal polymer concentration in this area can be obtained, which can be controlled in the range of 1000mg/L to 1500mg/L. The polymer concentration can be adjusted according to the specific situation of each oil well. Based on a polymer injection field test in the polymer injection test area and reservoir data simulation in this area, detailed data analysis was carried out on the law of polymer flooding. It is predicted that after the application of secondary polymer injection, the following information can be obtained by comparing with subsequent water flooding. The concentration of primary slug injection was controlled at 2000 mg/L, and the slug volume was kept at 0.08 PV. After continuous injection for one year, the slug was adjusted to secondary slug. The concentration of secondary slug injection was controlled at 1500mg/L, the slug volume was maintained at 0.18PV, and 0.09 PV was injected into the well each year for two consecutive years. The actual polymer dosage was 2000mg/L×0.08PV+1500mg/L+0.18PV=430mg/L•PV. This is the best secondary polymer injection, increasing well recovery by 3%, up to 4%, and increasing oil production by up to 4%, Increased crude oil production can reach$32.67 \times 10^4$t~$43.56 \times 10^4$t.

### 4.4 Binary compound flooding

Based on the field experience, the two alkali types, Na _2, CO _3 and NaOH, have strong application performance and can effectively limit the interfacial tension between oil and water. After adding the alkali agent into the polymer solution, the hydrolysis strength of the polymer is improved, and the strong alkali NaOH can make the polymer produce stronger hydrolysis effect in a short time, and increase the viscosity. The weak alkali [Na] _2 [CO] _3 has a weak effect on the polymer, and there is no obvious change in the viscosity. However, the strong alkali NaOH can hydrolyze the polymer and improve the viscosity, but the further hydrolysis of the polymer will be affected by calcium ions and magnesium ions, producing precipitation, which will affect the binary composite flooding and increase the dosage of alkali agent. Therefore, after comprehensive economic benefits and stickiness, choose to use [Na] _2 [CO] _3[5]. Therefore, the formula system of binary composite flooding can be arranged into; [Na] _2 [CO] _3+ Mo-4000. If the chemical dosage remains the same and the water composition remains the same, maximum reservoir recovery can be achieved by using a mixture of alkali and polymer first followed by polymer protection slug. At the same time, the application of alkali and polymer dual composite flooding, compared with water flooding or pure polymer flooding, can achieve stronger effect in terms of oil increase and precipitation, and is more suitable for oil exploitation in polymer injection test area.

## 5. Conclusion

Although this paper analyzes the subsequent water flooding technology of polymer flooding from all aspects, it still needs to take the actual situation of oil field as the standard in practical application, reasonably absorb the theoretical content of this paper, and optimize the current oil exploitation scheme. It is hoped that this paper can provide help for more front-line technicians, improve the exploitation level of China's oil fields and promote the stable development of China's industry.

## Reference

1. Yang Jun. Total factor evaluation of polymer flooding injection process in high water cut oil field [J]. Oil & Gas Field Surface Engineering, 201, 40(11):18-20.
2. Rong Junfeng, LI Longyang, BA Penghui, et al. Fenton oxidation and activated carbon Adsorption for PAM wastewater treatment in oilfield polymer flooding [J]. Applied chemical industry, 2020, 49 (04):940-944.
3. LI Bo. Subsurface injection and adjustment technology of polymer flooding in Lamadian Oilfield [J]. Chemical Engineering and Equipment, 2021 (10):107-109.
4. Ma Jun, HE Yaqi, YU Zhongchen, et al. Research on structure and performance characteristics of polymer flooding wastewater filter bed [J]. Industrial water & wastewater, 2020,51(05):45-49.
5. YUAN Yujing, LIU Yigang, Meng Xianghai, et al. Fine & specialty chemicals, 2020,28(05):19-22.