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Research and Application of Water Plugging and Fracturing Technology in Jurassic Bottom Water Reservoirs

Xiaoming Ren, Wenfei Yang, Dong Chen, Tao Liang

Ninth Oil Production Plant of PetroChina Changqing Oilfield Branch, Yinchuan, Ningxia, 750006, China

Abstract

The Jurassic oil reservoir in Wuqi is a typical bottom water oil and gas reservoir. The overall law of vertical distribution of oil and water is that oil layer, oil-water same layer, poor oil layer, water layer and dry layer are intertwined and distributed, most of which are low porosity and low The reservoir with poor permeability requires fracturing to start production. There is a problem that the bottom of the fracture is too close to the water layer or directly presses through the water layer, resulting in high water cut or clear water, resulting in the loss of productivity of the oil well, and this problem affects the development effect of the Jurassic. the biggest problem. In this paper, aiming at the shortcomings of the technology of reducing the construction displacement and controlling the rise of the subsidence agent, a new plugging agent is proposed. The plugging agent has the characteristics of water blocking and oil permeability. Significant results have been achieved initially.

Keywords

Control Rallies; SN Plugging Agent; Consolidation in Water; Dissolution in Oil.

1. Introduction

The Jurassic in the WQ oilfield is a typical paleochannel reservoir, and the reservoir is a low-porosity, low-permeability and thin reservoir. The porosity of the Y9 reservoir is between 11% and 16%, and the average permeability is 1.52×10-3μm2; the Y10 reservoir The porosity is between 12 and 18%, and the average permeability is 1.56×10-3μm2. The general rule of the vertical distribution of oil and water in the Y9 and Y10 reservoirs is that the oil layer, the same oil and water layer, the poor oil layer, the water layer and the dry layer are intertwined and distributed, and the Y9 and Y10 reservoirs have bottom water. According to the actual situation of the area and the minimum construction displacement that hydraulic fracturing can achieve, the control of vertical fracture height still cannot achieve effective exploitation of this reservoir, that is, because the bottom of the fracture is too close to the water layer or directly presses through the water The formation causes high water cut or produced water, resulting in the loss of productivity of the oil well.

2. Water Plugging Fracturing Mechanism in Bottom Water Reservoirs

At present, the technical direction of fracturing stimulation of bottom water reservoirs is mainly to control the extension of artificial fractures in the direction of fracture height, mainly through:

(1) Use the construction displacement to control the crack height

This method is mainly based on the proportional relationship between the construction displacement and the crack height, that is, the larger the displacement, the higher the crack to control the crack height.

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In the Cotton Valley area of the United States [1], through logging the temperature after fracturing, it is concluded that the construction displacement and the fracture height have the following relationship:

$$H=7.23\times e1.03Q$$

where:

H-crack height, m;

Q-construction displacement, m^3/min;

e - the base of the natural logarithm.

In order to avoid excessive cracks, the construction displacement is generally reduced as much as possible when the construction conditions allow, so as to control the excessive extension of artificial cracks in the height direction. In recent years, through continuous exploration, the fracturing construction displacement of the Jurassic low-water reservoir in Wuqi has been reduced from 1.0-1.2↓0.6-0.8m3/min, and the number of wells with direct water breakthrough has been greatly reduced (24↓3), with remarkable results. . However, due to the different formation conditions in different regions, the control effect of reducing the construction displacement on the fracture height is also different.

(2) Use high-density sinking agent to establish artificial interlayer to control the extension of fracture height

After pre-hydraulic excavation of the formation, the sand-carrying liquid is injected into the high-density subsidence agent to make it sink and gather at the bottom of the fracture to form an artificial barrier, so that the pressure fracture extends and expands inside the target layer to prevent the hydraulic fracture from going down. Extends into the bottom water layer. At present, the commonly used subsidence agents to control the vertical and downward extension of cracks are silt or silty pottery, which have been widely used in on-site construction. Field application shows that the artificial barrier formed by them has a good effect in controlling fracture extension, but because the artificial barrier formed by them still has a certain permeability, it cannot effectively prevent the bottom water from coning into the wellbore. In recent years, the author has tested 8 wells of fracture-controlled high-pressure fracturing technology in the mining area. The implementation effect is unstable, and some wells still show the characteristics of rapid water breakthrough after fracturing.

In view of the problems of the above-mentioned joint height control technology, the author's work team has studied a special resin plugging agent, which has the characteristics of water resistance and oil permeability. Based on this, the water plugging fracturing technology for Jurassic bottom water reservoirs was formed. Considering the characteristics of fracturing operation, the design adopts a double-cladding layer design, and the outer layer is a water-soluble coating film, which is designed for 72 hours at a certain temperature. Dissolves automatically in water. The inner layer is an oil-soluble and water-encapsulating coating film. When encountering water, it bonds with each other to form a strong sealing feature, and when encountering oil, it automatically degrades to form a flow channel.

3. Research on the Performance of Plugging Agent

According to the oil-water distribution characteristics of bottom water reservoirs and the technical requirements for water plugging and fracturing of bottom water reservoirs, the water plugging materials should have the following properties:

(1) The water blocking material is cemented and consolidated in contact with water.

(2) The time of consolidation is greater than the time of drainage, and no consolidation or weak consolidation occurs within 3 days.

(3) It has good water blocking performance after consolidation.

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(4) After consolidation, it is soluble in oil at the temperature of the oil layer.

The SN plugging agent can be consolidated by adding water at 50 °C, and it does not dissolve in water after consolidation, and the consolidation property is stable.

After consolidation, add kerosene and let it stand for 2 hours at 50 °C. It is found that the consolidated sand column is dispersed and the proppant is completely separated (as shown in Figure 1).

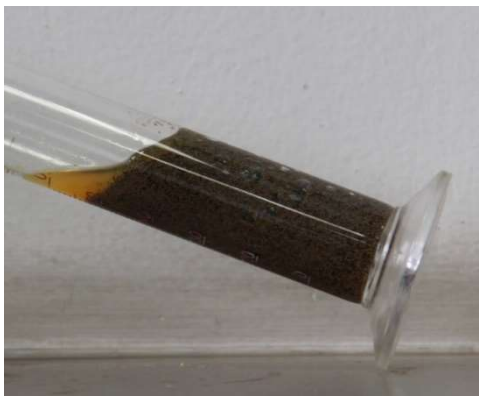

Figure 1. The consolidated plugging agent was added to kerosene and left for 2h at 50℃

In order to simulate the solidification environment in the fracture, a special experimental device was used to verify the water-blocking and oil-penetrating properties of the SN plugging agent.

Alternate flooding experiments with distilled water and kerosene in pure cementitious sand cores.

Select blocking agent: 50℃, 16-26 mesh, 70g;

Laying method: pure plugging agent;

Experimental temperature: 50℃;

Displacement rate: 7ml/min.

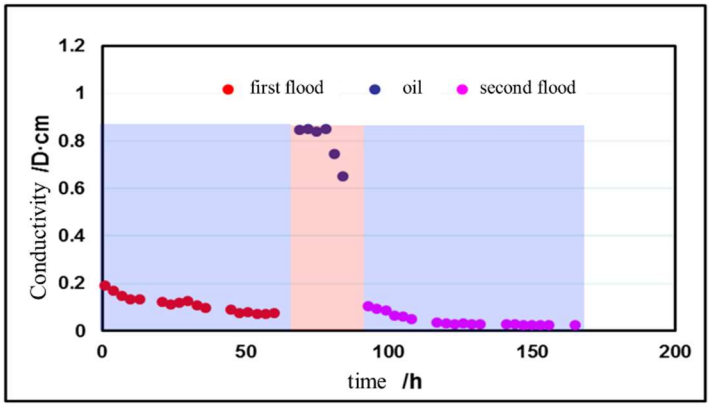

Figure 2. Results of displacement experiments in sand cores with pure sealing agent

The test results show that the water permeability of the mounting medium gradually decreases under the action of closed compaction and contact with distilled water for curing. The mounting medium is dissolved by crude oil, and the single-phase conductivity of the oil phase is significantly higher than that of the water phase. After the mounting medium is dissolved, it contacts with distilled water, which can re-cement, gradually reducing the water seepage capacity, even lower than the first stage.

The density of the sealing agent particles is in the range of 1.1~1.3g/cm3, which is close to the density of the fracturing fluid, and the "water repellent" characteristic is obvious. There are problems of agglomeration and floating when directly added to the sand mixer. However, adding SN blocking

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agent to the guar gum base liquid can be configured into a stable suspension, and this method can be used to add the mounting agent during construction.

Figure 3. Test diagram of SN plugging agent + guar suspension

4. Design of Sealing Construction Technology

The bottom water fracturing technology using SN plugging agent generally adopts a two-stage fracturing construction design. The first-stage water plugging is intended to make the SN plugging agent or the SN plugging agent-coated proppant form a strong shield at the lower part of the fracture profile, blocking the way for water to directly enter the wellbore along the fracture. At the same time, the "barrier layer" placed in the oil layer recovers the seepage ability after being dissolved by the crude oil. The second-stage repeated stimulation adopts conventional sand fracturing, aiming to form fractures with strong conductivity in the upper part of the fracture profile, so as to ensure that the oil well has a high fluid production.

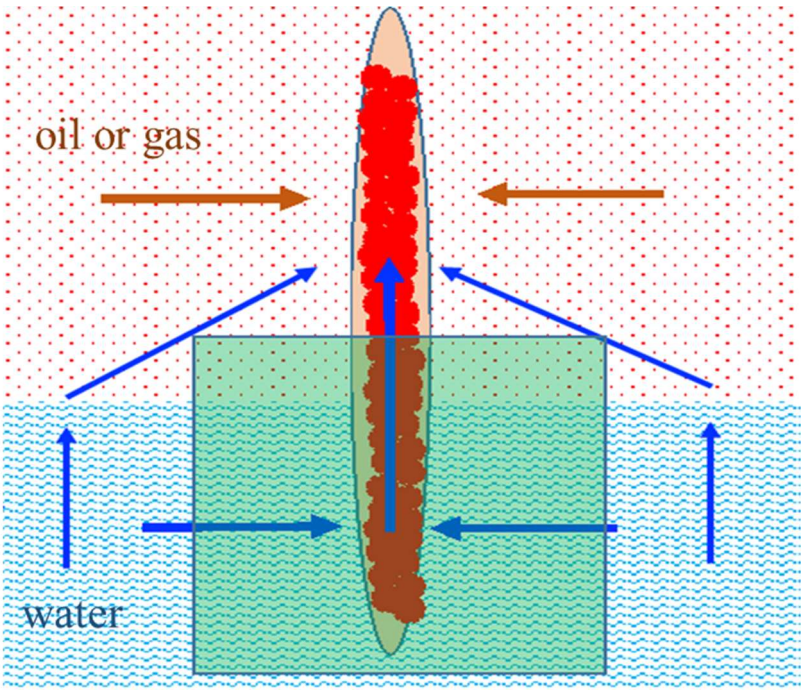

Figure 4. Schematic diagram of oil and water production after bottom water fracturing

5. Field Application

SN plugging agent has been tested in 8 wells in Changqing Oilfield, and 6 wells have been successfully tested. It has excellent performance in precipitation and water control. In the process of new well fracturing and oil testing, it effectively solves the contradiction between the stimulation

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strength and the communication of bottom water between fractures. Dewatering of old wells was generally successful, with an average daily oil increase of 1.2t, which is more effective than other water plugging and fracturing technologies. However, some wells did not increase oil due to the problem of excessive drop in fluid volume. It was preliminarily judged that the distribution of oil and water in old wells was disordered after flooding. lead to excessive drop in fluid volume.

Example 1: Well S116 is an oil pre-exploration well, which is a typical thick bottom water oil well. The fracturing was put into production. The fracturing process was to seal the bottom water and fracturing. Two-stage fracturing was adopted. The first stage construction mainly implemented water plugging, adding 5m3 of sand, and using SN sealing agent (particles, particle size about 1-2mm) 2t , the sand ratio is 15%, the displacement is 1.4m3/min; the second-level sand is 15m3 (pure quartz sand), the sand ratio is 15%, and the displacement is unchanged. According to the comparison of array acoustic logging before and after pressure (Fig. 5), it is shown that the artificial fractures have penetrated into the bottom water layer vertically, but no water has been seen after production. A reliable water blocking barrier is provided, which blocks the way for bottom water to be directly produced along the fracture.

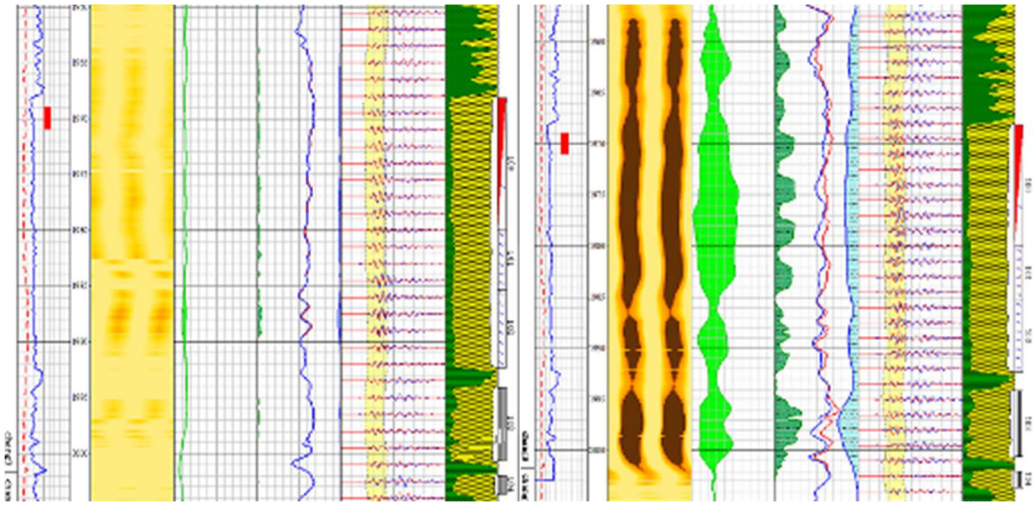

Figure 5. Comparison of array acoustic logging results before and after fracturing in Well S116

At the initial stage of production, Well S116 had an average daily fluid production of 10.2m3, daily oil production of 5.4t, and comprehensive water cut of 38.3%. After 211 days of production, the daily production was 2.97t, and the water cut was stable at about 38% without major fluctuations. The water plugging fracturing effect was good. (Figure 6).

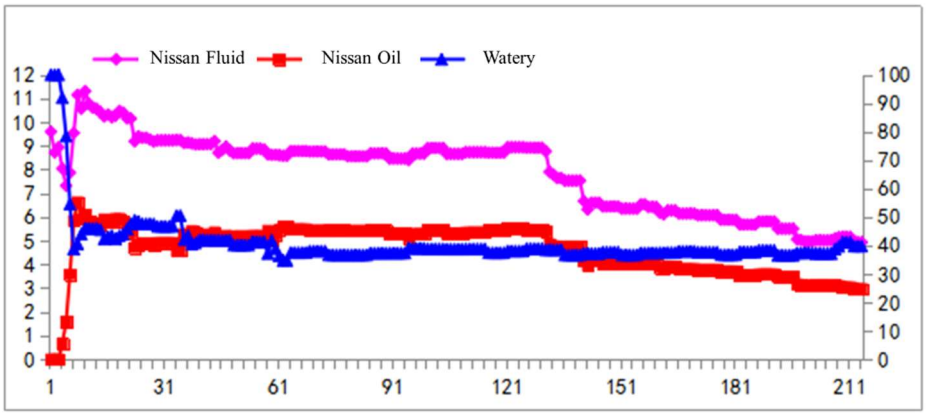

Figure 6. Production performance of Well S116 since it was put into production

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Example 2: The X240 Jurassic reservoir is a typical water reservoir, and Well W264-24 is located at the edge of the reservoir. In August 2012, the fracturing of the Y10 layer was put into production. The fracturing construction parameters: sand volume 3m3, sand ratio 10%, displacement 800L/min, initial daily fluid production 7.3m3, daily oil production 5.1t, water content 17.8%.

In June 2014, the measures of fracturing and plugging were implemented. Construction parameters: sand addition of 5m3, sand ratio of 15%, and displacement of 1.0m3/min. The 2m shale interlayer between the oil layer and the water layer in this well has a weak shielding effect and cannot prevent artificial fractures from breaking into the bottom water layer. After the measures, the water content rose rapidly, the daily liquid production was 10.7m3, and the water content was 100%.

Recently, the fracturing technology of sealing and sealing water has been tested. The water plugging fracturing process adopts SN plugging agent + SN water plugging agent coated with proppant, and the construction is divided into two-stage fracturing.

First-stage water plugging: mix 1t 150 mesh mounting agent into 20m3 guar gum base liquid, use cross-linking liquid containing mounting agent to carry water blocking agent coated ceramsite 5t, sand ratio 10%, displacement 1.0 m3/min. The intention is to fill the pores in the support cracks formed by the coated ceramsite, so that the support cracks placed in the water layer can form a strong shield, and the support cracks placed in the oil layer will recover the seepage ability after being dissolved by the oil.

The second-level repeated transformation: the amount of sand added is 3m3, the sand ratio is 15%, and the displacement is 1.0m3/min.

After the measures in Well W264-24, the initial daily liquid production dropped from 10.27 to 3.74m3, and the water cut was reduced to 60%. The precipitation effect was outstanding. The well was pure water before the measure, and the sealing agent mainly played a plugging feature after the implementation of the sealing and fracturing. The oil-water displacement effect made the oil dissolve the sealing layer weaker, and the sealing agent blocked the pores of the channels and supporting fractures. It cannot be relieved in a short time, resulting in a significant drop in the liquid volume after the measures. (Figure 7)

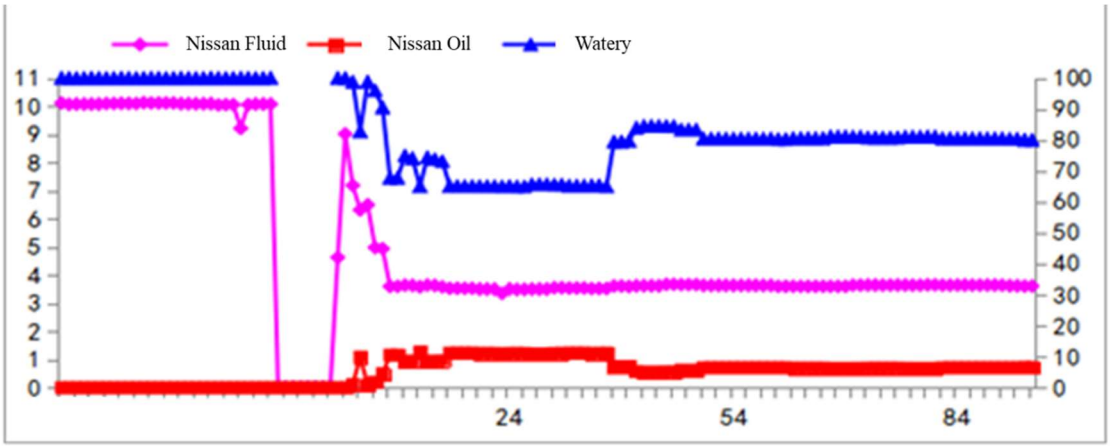

Figure 7. Tracking effect of fracturing measures for bottom water plugging in Well W264-24

Example 3: W268-30 bottom water coning leads to high water content. SN plugging agent-coated proppant is used for water plugging and fracturing. The dosage is 3t. After fracturing, the comprehensive water content is reduced from 90.3% to 67%, and the fluid volume is basically stable. The oil increase is 2.1t. (Figure 8).

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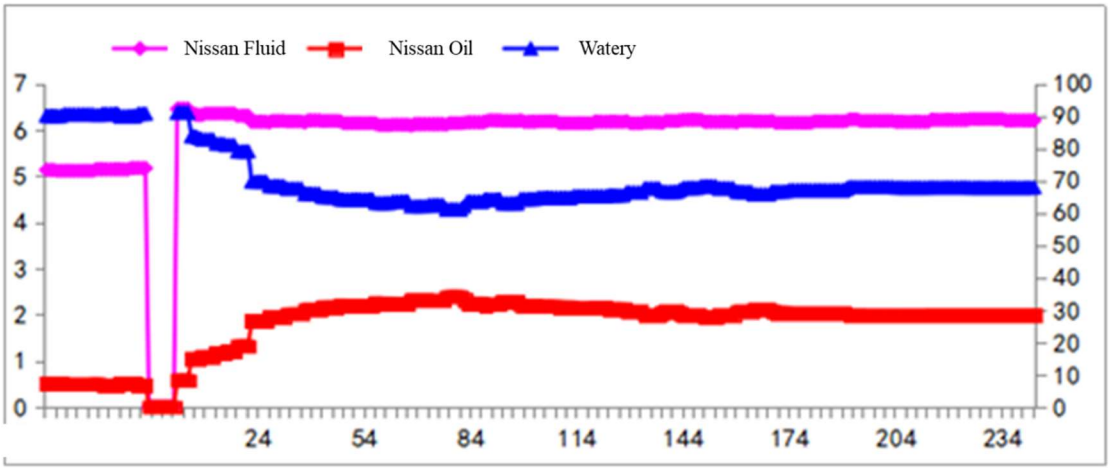

Figure 8. Tracking effect of fracturing measures for bottom water plugging in Well W268-30

6. Conclusion

1) Reducing the construction displacement can control the excessive extension of the fracture height and reduce the risk of the fractures directly communicating with the bottom water. However, due to the different stratum conditions in different regions, the control effect of reducing the construction displacement on the fracture height is also different, and it is unavoidable to press the bottom. water.

2) The artificial barrier layer formed by the high-density subsidence agent control rallies technology has a good effect in controlling fracture extension, but because the barrier layer also has a certain permeability, it cannot effectively prevent the bottom water from coning into the wellbore.

3) SN plugging agent has the characteristics of being solidified in water and dissolved in oil after consolidation. The application in bottom plugging water fracturing can form an effective shield in the fracture, block the way of water flowing directly along the fracture, and can effectively avoid blocking the oil outlet during the water plugging process.

4) The distribution of oil and water in new wells is clear up and down. Using SN pure plugging agent and SN plugging agent-coated proppant for water plugging and fracturing can achieve good results, which can better block the water outlet without affecting the fluid volume. However, due to the irregular distribution of oil and water in the old well after the production water flooding, the dominant pores are mainly water. The use of SN pure plugging agent can block the bottom water and also block some pores on the fracture wall, blocking the seepage of the matrix to the fracture. way. It is recommended to use SN plugging agent coated proppant for water plugging and fracturing in old wells.

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