Research and Application of Water Soluble Temporary Plugging Agent

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Abstract. With the wide application of temporary plugging agent in new oil and water wells, China's research on water-soluble temporary plugging technology can better deal with various problems in construction. Now we have four tests on the indicators of water-soluble temporary plugging agents. First, the water soluble temporary plugging agent was tested for dissolution in five different liquids at different temperatures. Secondly, the flow tester is used to measure the breakthrough pressure to further determine its strength. Again, the water insoluble matter in the water-soluble temporary plugging agent is tested for damage. Finally, in order to further determine the differential pressure performance of the temporary plugging agent, the temporary plugging agent is tested in the field, and the test result satisfies the requirement of 80 Mpa. The test results have met the engineering requirements, and the on-site test of the temporary plugging agent is consistent with the actual engineering standards, which has important guiding significance for the field oil and gas field mining.

1. Introduction

In foreign EOR, 35% of the design of the solution uses polymers, and 60% of them are treated with cold glue [1]. The plugging agent is divided into different types according to the polymer: polyacrylamide gel sealant, polyacrylamide gel sealant, lignosulfonate gel sealant, biopolymer gel Water blocking agent and amphoteric polymer jelly water blocking agent. And there is considerable development in the study of water-soluble temporary blocking agents [2].

Various types of temporary plugging agents have been greatly developed under the impetus of fracturing technology. The ensuing problem is that the oil and gas resources owned by China do not have a corresponding proportion to the oil and gas resources that can be mined. A significant portion of the main oil fields have been completely flooded, making oilfield development increasingly difficult. Through field tests, it is shown that, on the basis of ensuring the sustainable development of the oil well, by adding a water-soluble temporary plugging agent before the fracturing construction, a new joint is opened, and after some temporary oil plugging is applied, the oil production is greatly improved. The water-soluble temporary blocking agent has excellent water solubility and has less damage to the underlying layer. Therefore, the optimization and development of temporary plugging agents has become an inevitable problem in oil and gas engineering. Studying new low-injury temporary plugging agents has become one of the key research directions of oilfield engineering.

This paper mainly through a large number of indoor evaluation and on-site application research methods, as well as four performance tests on water-soluble temporary plugging agents, using
experimental methods to test the water-soluble temporary plugging agent showed excellent performance, the test results show that the water-soluble Temporary plugging agent plays a key role in crack steering [3].

2. mechanism
In the construction process, a control agent is added to the formation in real time, which is a viscoelastic small solid of nitrile solids, following the principle that the fluid flows in the direction of the minimum blocking force. The control agent particles enter the fracture or high permeability layer in the formation, creating a filter cake bridge in the high permeability zone, which can form a pressure difference above the fracture fracture pressure. The working fluid cannot enter into the cracks and high permeability zones, so that the fracturing fluid enters the high stress zone or the new crack zone, causing the new seam to be produced and the proppant to be laid.

By delivering high-intensity water-soluble temporary plugging agent one or more times, in hydraulic fracturing, the liquid pressure automatically finds the best oil-rich enriched dessert zone, and then presses the first crack and uses granular high-strength water-soluble The temporary temporary plugging agent blocks the first crack, continues to pump into the fracturing fluid, raises the pressure, automatically selects the second-level dessert zone, and presses the second crack [4]. In the same way, multiple slits such as the third slit are sequentially pressed to realize the multi-crack fracturing of the natural selection dessert (Figure 1).

Figure 1. Inter-segment/slot temporary blocking effect diagram

2.1. Temporary plugging and multi-cracking technology for water-soluble segments
Firstly, according to the geological conditions of the reservoir, after the fracturing construction, the liquid oil pressure is automatically used to find the best oil-rich dessert zone in each section, and the first crack is pressed. This slit is generally the best in this section (porosity or micro-crack development, etc.), the easiest to open the reservoir, which is the "dessert" reservoir (this is the meaning of natural selection of dessert), the first open After the joints are sewed and modified, a special high-strength water-soluble temporary plugging agent is put in, and the first crack slit is temporarily blocked. We should continue to pump the liquid, squeeze inside the seam, and press the second crack in the second dessert position. In the same way, multiple slits such as the third slit and the fourth slit are sequentially pressed to realize the multi-crack fracturing of the natural selection dessert in the segment. In a large section, it is generally possible to form 3 to 5 slits, and a plurality of cracks interfere with each other through the slits, further increasing the complexity of the cracks.

3. Four tests for temporary blockers
3.1. Dissolution test of temporary plugging agent
A series of high-strength water-soluble joint temporary plugging agent is made of friendly-environmentally polymer material through a variety of processes, following the principle that the fluid flows in the direction of the minimum blocking force, and the filter cake bridge is generated in the crack, which can be formed higher than The pressure difference of the crack rupture pressure makes it
impossible for the subsequent working fluid to enter the crack zone, thereby causing the liquid to enter the high stress zone or the new crack layer, and promote the new seam\cite{5}. The temporary plugging agent is completely dissolved in the fracturing fluid or formation water after the construction is completed, and no pollution is caused to the formation. (Figure 2).

Table 1. A Series high-strength water-soluble seam temporary plugging agent.

| Attributes         | Numerical value          |
|--------------------|--------------------------|
| Exterior           | Black powder             |
| density g/cm$^3$   | 1.0-1.4                  |
| Particle size      | 20-60 item               |
| Dissolution time, h| 2-48                     |
| Solubility rate, % | $\geq 98$                |
| Compressive strength, MPa | $\geq 40$           |

B series high-strength water-soluble seam temporary plugging agent (chemical separator) is made of environmentally-friendly polymer materials through various processes. The temporary plugging agent particles produce filter cake bridge in the crack mouth, which acts as a sealing effect. The temporary plugging agent is completely dissolved in the fracturing fluid or formation water after the construction is completed, and no pollution is caused to the formation.

Table 2. B Series high-strength water-soluble slit temporary plugging agent (chemical separator).

| Attributes         | Numerical value          |
|--------------------|--------------------------|
| Exterior           | Black powder particles   |
| density g/cm$^3$   | 1.0-1.4                  |
| Particle size      | 3-8 mm                   |
| Dissolution time, h| 2-72                     |
| Solubility rate, % | $\geq 98$                |
| Compressive strength, MPa | $\geq 40$           |

C series high-strength water-soluble temporary blocking ball is made by using environmentally-friendly polymer materials through various processes to temporarily block the ball into the cracks or blastholes in the formation, forming a bridge and forming a pressure difference higher than the fracture pressure of the crack. The subsequent working fluid can not enter into the crack, so that the liquid enters the high stress zone or the new crack layer, prompting the creation of a new seam. The temporary blocking ball is completely dissolved in the fracturing fluid or formation water after the construction is completed, and no pollution is caused to the formation.

Table 3. C Series high-strength water-soluble temporary blocking ball.

| Attributes         | Numerical value          |
|--------------------|--------------------------|
| Exterior           | Brown smooth sphere      |
| density g/cm$^3$   | 1.1-1.5                  |
| Particle size      | 6.35 mm, 9.52 mm, 12.70 mm, 15.87 mm |
| Dissolution time, h| 2-96                     |
| Solubility rate, % | $\geq 98$                |
| Compressive strength, MPa | $\geq 40$           |
3.2. Dissolution test of temporary plugging agent

The water-soluble temporary plugging agent used in the fracturing process plays a key role in the fracturing process \[6\]. It is related to the success or failure of the fracturing construction. The strength of the temporary plugging agent is the key. The test evaluation report mainly tests the breakthrough pressure. A flow tester is used to determine the breakthrough pressure to determine the strength of the temporary plugging agent. If you need to ensure the strength of the temporary plugging agent, you need to use the most advanced automatic flow tester in China, and the data processing uses advanced computer software processing technology.

| Core number | Drug volume (cm³) | Simulated thickness (cm) | Breakthrough pressure (MPa) | Remarks |
|-------------|-------------------|--------------------------|----------------------------|---------|
|             | 01                |                          | 44MPabreakthrough           | There is liquid outflow at the beginning of the injection phase, and after 50-60ml, it is completely blocked. |
|             | 02                |                          | 23MPabreakthrough           | Basically, no blockage was formed and no pressure could be read. |
|             | 03                |                          | no                         | There are floes flowing out and there is no blocking. |
|             | 04                |                          | 0.7                        |         |

Table 4. Dispersed state breakthrough stress test results.

It can be seen from the above experimental results that after the simulated compaction, the thickness of the filter cake is more than 1 cm, and the dispersed state agent can form a plugging filter cake by secondary cross-linking, and the breakthrough pressure is 23 MPa.

| Core number | Thickness (cm) | Breakthrough pressure (MPa) | Remarks |
|-------------|----------------|-----------------------------|---------|

Table 5. Filter cake breakthrough stress test results.
The advection pump upper limit has been reached. Only a small amount of liquid flowed out before the breakthrough.

1. In the case of dispersion, the temporary plugging agent cannot break through 23MPa when the compaction thickness is greater than or equal to 1cm. When the compaction thickness is less than 0.7cm, it cannot form effective sealing. There is no breakthrough pressure, just as the liquid flows out.

2. In the case of cementation, the temporary plugging agent cannot break through 23MPa when the thickness is greater than or equal to 0.9cm. The breakthrough pressure is 12.3MPa when the thickness is 0.5cm, and the breakthrough pressure gradient is greater than 2.175MPa/mm.

3. If the thickness of the filter cake increases, the breakthrough pressure is increased. The highest breakthrough pressure is 44 MPa. If you want to obtain high breakthrough pressure, you can apply the method of increasing the thickness of the filter cake.

### 3.3. temporary blockage injury test
Prepare a series of measurements for water insolubles in the temporary plugging agent. Then, under the same experimental conditions, do parallel experiments to obtain the results.

| Measurement item                  | sample 1  | sample 2  | sample 3  | sample 4  |
|-----------------------------------|-----------|-----------|-----------|-----------|
| Centrifuge tube quality g         | 23.3422   | 23.0987   | 22.7865   | 22.9743   |
| Sample quality g                  | 0.2       | 0.2       | 0.2       | 0.2       |
| Centrifuge tube and sample quality after baking g | 0.0019 | 0.0013 | 0.0018 | 0.0016 |
| Water insoluble matter quality g  | 0.0019    | 0.0013    | 0.0018    | 0.0016    |
| Percentage of water insolubles    | 0.95%     | 0.65%     | 0.90%     | 0.80%     |
| Arithmetic mean                   |           |           |           | 0.83%     |

Then, the permeability of the temporary plugging agent was restored. Four groups of artificial cores with similar permeability were selected. Under the same test conditions, the permeability recovery in HPG fracturing fluid at different temperatures was determined. When the permeability is not much different, as the experimental temperature increases, the solubility of the temporary plugging agent in the fracturing fluid increases, and the permeability recovery rate increases [7].

### 3.4. Temporary plugging agent strength field test
Due to the limitation of indoor experimental conditions, in order to further determine the pressure difference performance of the temporary plugging agent, a high-pressure pipeline was separately prepared at the site, and a cemented temporary plugging agent was installed, with a length of 0.5 m.

The test well is a Su-53-74-44H well. After the first and second stages of construction, the third-stage sliding sleeve is opened, the well is closed, the oil pressure is 20 MPa, the ground high-pressure pipeline is relieved, and the high-pressure pipeline equipped with the filter cake is replaced. Connect the entire ground high pressure process [8]. When ready, open the wellhead gate, start the fracturing
pump truck, test the small displacement, and set the pressure limit to 105MPa (105MPa pressure at the wellhead). The test curve is shown in Figure 3.

![Figure 3](image)

Figure 3. Temporary plugging agent withstand pressure difference field test curve

4. Summary

Through a large number of indoor evaluation and field application research, we conclude that the high-strength water-soluble temporary plugging agent not only has high pressure bearing capacity, high plugging rate of filter cake formed in the formation, and good sealing effect. And the solubility is good, the temporary blocking agent can be completely dissolved in the fracturing fluid, does not cause secondary damage, and the time is controllable, the method is simple to operate, and the surfactant is contained, which is favorable for returning.

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