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Application of Temporary Plugging Stimulated Reservoir Volume Fracturing in Mahu Conglomerate Tight Oil

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APPLICATION OF TEMPORARY PLUGGING STIMULATED RESERVOIR VOLUME FRACTURING IN MAHU CONGLOMERATE TIGHT OIL

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Abstract. On account of the influence of early technical level and transformation concept, the production of the test horizontal wells has been improved to a certain extent, but there are still some problems, such as low pressure decline, low sustainable and stable production capacity. Refracturing technology is one of the main measures to improve the output of old wells in domestic and foreign oilfields at the moment. However, the horizontal wells put into production in early stage of Mahu were segmented with open hole packer and ball sliding sleeve. Restricted by the current wellbore conditions, forced mechanical segmented refracturing could not be achieved. People make use of the high-strength temporary plugging system to automatically select geological dessert, realize multiple inter-layer and intra-layer steering, improve the complexity and sweep volume of artificial fractures, and achieve the partial function of stimulated reservoir volume fracturing, which has become the effective increase production technology and means.

1. Introduction

Dense oil widely distributed resources are rich in our country, the total resources reach to 110 ~ 13.5 billion tons of much starker choices-and graver consequences. The outline of the 13th five-year plan will push deep-sea oil exploration and development of tight oil sands and comprehensive utilization of shale gas into the list of 100 major projects and projects that China plans to implement in the next five years. From 2010 to 2015, unconventional reserves discovered in Xinjiang oilfield account for more than 65%, and tight oil has become the most realistic replacement field for the increase of reserves and production in Xinjiang oilfield.

Mahu conglomerate dense oil is buried deep, and there are many problems, such as deep burial, undeveloped natural cracks, strong heterogeneity, high stress difference, high pressure coefficient and so on. It is a new field of compact oil development at home and abroad, and the difficulty of development and utilization is obviously tougher than that of other domestic tight oils. The early main body adopts the naked-hole packer + pitching sliding sleeve stage fracturing process, according to the geological characteristics and reconstruction difficulties of this type of reservoir, but under the characteristics of reservoirs such as low porosity, low permeability and natural fracture, the reservoir matrix. The conventional fracturing technology with poor fluid supply capacity to cracks, large crack spacing, medium construction displacement, and medium fracturing scale did not achieve the expected increase in production.



Since the launch of the capacity building development test in 2015, through drilling bridge plug section, small bunch of perforating construction of large displacement and crack spacing points to ensure that the segment fracture clusters more efficiently and crack extension, and combining with the plug type sand process, the prompt for the longitudinal cracks and distal filling to increase fracture diverting capacity, to realize the reservoir volume can increase energy storage and transformation of the purpose, to ensure the long-term effective fracturing.

We take the current Mahu area as the successful example of development of horizontal well fracturing + stimulated reservoir volume fracturing, early for open hole completion of horizontal wellbore conditions, geological dessert features using liquid automatic selection, temporary plugging agent can meet the temporary plugging current-limiting and between layers of temporary plugging fracture shift, effectively realize multiple turns between layers and layers, improve the complexity and volume of artificial cracks, and achieve some functions of imitation “stimulated reservoir volume fracturing”^[1,2].

2. Oil reservoir geological features

The permeability of tight oil in Mahu conglomerate is low, especially in the north slope of Ma Lake, which is only 1.08~1.44mD; and the pore configuration is fine, the porosity is less than 10%, the throat radius distributes mainly in 0.1~0.3 μ m, and the formation fluid fluidity is limited^[3]. Compared with other unconventional oil and gas reservoirs in China^[4-6], Mahu conglomerate tight oil still faces great challenges in stimulated reservoir volume fracturing because of its unique lithology and geological characteristics, which are mainly reflected in the following three aspects:

(1) The natural cracks are not developed, the rock is partially plastic, and the horizontal two-direction stress difference is large (about 10~22MPa), and the fracture morphology is mainly plane fractures, which is difficult to achieve the volume transformation of complex fracture network.

(2) The mechanism of burial in deep reservoirs and conglomerate strata is complicated. When multi-cluster perforation in the section is fracturing, the over-pressure is frequent in the cracking stage, and the construction displacement is limited. However, it is difficult to achieve the cracking and extension of multi-cluster cracks with low displacement, which affects the effect of fracture formation, reduces the cutting degree of reservoir and affects the effect of fracturing transformation.

(3) The gravel content is high, the particle size changes greatly, the crack surface is rough, the patterns of proppant migration are complex, the closing stress is high, the rock is a little bit soft, and the proppant is embedded seriously, which will affect the effective support of the artificial fractures.

3. Principle of temporary plugging stimulated reservoir volume fracturing technology

Temporary plugging stimulated reservoir volume fracturing, to be brief, is the stimulated reservoir volume fracturing, it refers to by one or more delivery within the period of high strength more than temporary plugging agent, forming filter temporary plugging the previous cracks, forcing open within the period of one or more new cracks, in order to gain more effective than conventional fracturing of single well volume, to maximize reservoir productivity, it is suitable for refracturing old horizontal wells in open hole or multi-cluster perforation completion of oil and gas wells.

3.1 The technique of temporary plugging multiple cracks in the section

This technology can be used to separate machinery, which can deal with the development of long span thin interlayer and the effective measures of reservoir with stress difference between layers, distribute the liquid injection efficiency of each section more reasonably, improve the efficiency of holes, reduce the interstitial interference caused by multiple fractures in dead oil zone at the same time, and further increase the complexity of fractures(Figure 1).



Figure 1. Schematic diagram of temporary blocking effect in section

3.2 The technique of temporary plugging in the joint to build branch joint & micro crack

This technique is able to overcome the influence of high stress difference on fracture extension caused by natural fracture failure zone, the addition of powder temporary plugging agent in the fracture forces the fracture to turn constantly, and a large number of micro-cracks and branch cracks are generated around the main fracture, thus forming complex grid cracks and achieving the purpose of volume transformat(Figure 2).

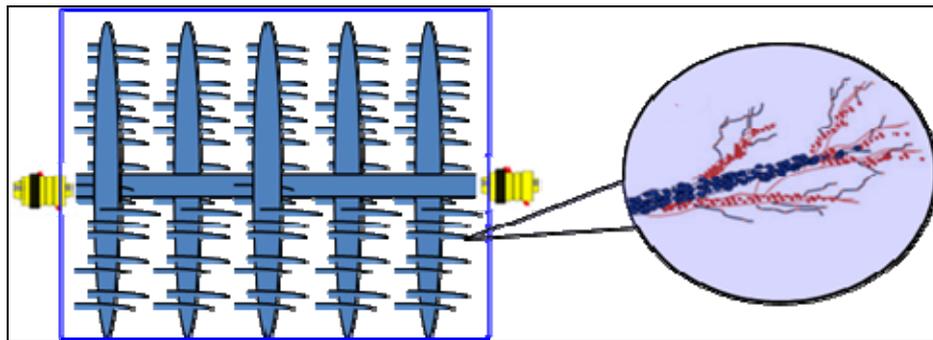


Figure 2. A schematic diagram of the effect of temporary plugging inside the joint to create branch joint & micro crack

4. Indoor evaluation of temporary plugging materials

4.1 Temporary plugging agent dissolution test

According to the dissolution test results of the temporary plugging agent in the laboratory, under the condition of approximate formation temperature 80°C and fracturing fluid used in the well, the temporary plugging material can be completely dissolved within 4.5 hours without reservoir pollution(Figure 3).

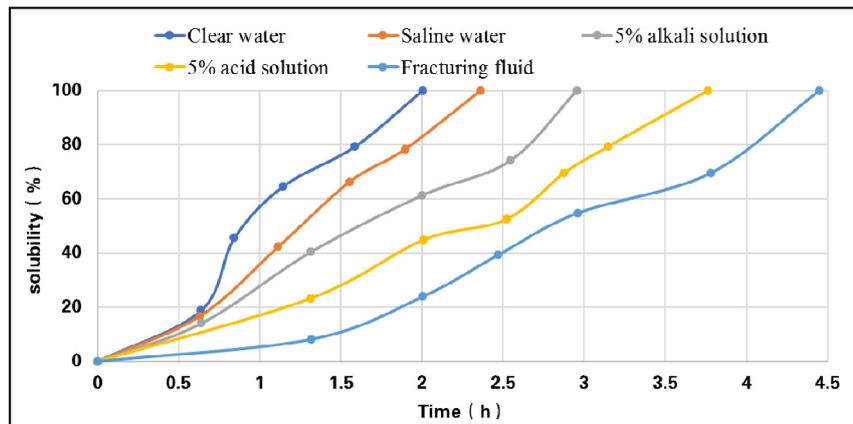


Figure 3. solubility curve at the temperature of 80°C

4.2 Temporary plugging strength test

According to the dissolution test results of the temporary plugging agent in the laboratory, under the condition of approximate formation temperature 80°C and fracturing fluid used in the well, the temporary plugging material can be completely dissolved within 4.5 hours without reservoir pollution.

4.2.1 Dispersion state breakthrough pressure test

The experimental test simulates the breakthrough pressure respectively are 5cm, 1cm, 0.5cm, and 0.7cm thickness after compaction, and the test was started after soaking fracturing fluid with a temperature of 80°C for 3-5 minutes. The experimental results are shown in table 1.

Table 1. Dispersion state breakthrough pressure test results

core number	01	02	03	04
drug volume (cm ³)	35.34	7.07	3.53	5.39
simulated thickness (cm)	5.0	1.0	0.5	0.7
breakthrough pressure (MPa)	44	23	/	0.7

It can be seen from the experimental results that when the thickness of the simulated compacted filter is more than 1cm, the dispersive agent will form a blocking filter by secondary cross-linking. The pressure of 23MPa can be broken through, and the thickness of the simulated compacted filter is less than 1 cm. The dispersive agent cannot effectively form a blocking filter and will flow out with displacement and continuous dissolution.

4.2.2 Test of precast cementation state breakthrough pressure

It can be seen from the experimental results in table 2 that dispersive agents cannot form effective plugging under the condition that their particle properties are less than 1cm. Therefore, filters are made by temporarily plugging agents dissolved in fracturing fluid and then air-dried. The thickness is 0.9cm and 0.5cm respectively.

Table 2. Filter breakthrough pressure test results

core number	05	06
simulated thickness (cm)	0.9	0.5
breakthrough pressure (MPa)	23.0	12.3

As can be seen from the above experimental data, once the filter is formed, the breakthrough pressure will be very high. When the thickness is greater than or equal to 0.9cm, the breakthrough pressure is 23MPa. When the thickness is 0.5cm, the breakthrough pressure is 12.3Mpa. For higher breakthrough pressure, we can make it by increasing the thickness of filter.

5.Field Application effect

The horizontal section length of XX well in Ma Lake area is 500m, the average section length is 90.5m, the total consumption of fracturing fluid is 1768.5 m³, the sand content is 180.3 m³, and the average daily oil output is 14.7t/d in the first three months. In March 2017, the oil well was temporarily closed because of insufficient liquid supply, and the cumulative production is 1339d, and the cumulative oil production is 6713.7t.

In October 2017, the XX oil well was artificially energized and temporarily plugging refractured. The amount of fracturing fluid entering the well was 8609 m³, the amount of sand was 370 m³, the temporary plugging agent was 1200Kg, the temporary plugging agent was 2240Kg, and the construction displacement was 8 ~10 m³/min. According to the underground micro-seismic monitoring data (Figure 4 and Figure 5), the microseismic events cover the whole well, and the temporary plugging turn is successful, and the multiple turns in the crack layer and between the layers are made, and the full transformation purpose is achieved.

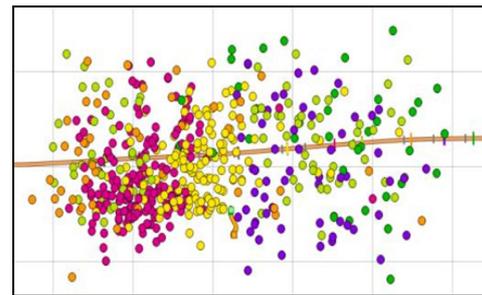
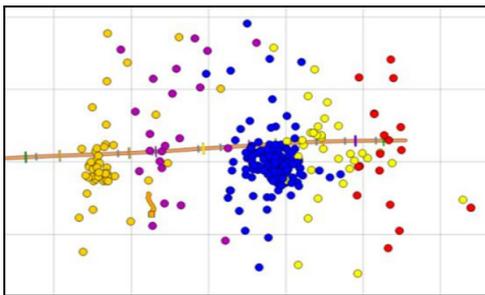


Figure 4. Microseismic results of initial fracturing Figure 5. Microseismic results

After the refracturing, the well produces 260d oil by blowing in. At present, 37.4t of liquid and 24.5t of oil per day are pumped by the machine, with a cumulative production of 328d and a cumulative production increase of 3090.3t, so the good transformation performance is achieved (Figure 6).

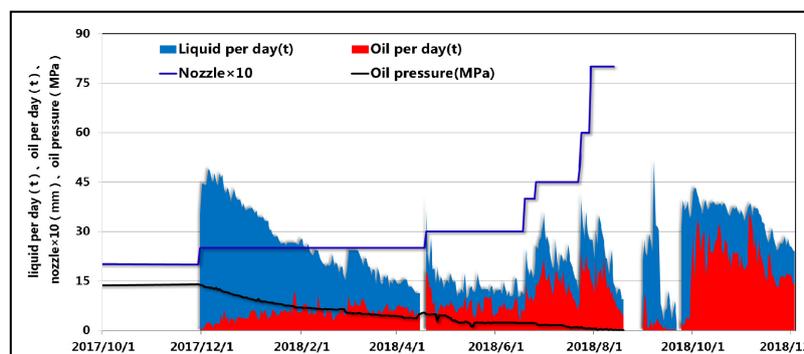


Figure 6. Production curve graph after repeated reconstruction of XX well

6.Conclusion and cognition

(1) Temporary plugging stimulated reservoir volume fracturing can not only promote fracture diversion within and between layers, but also naturally select geological sweet spot targets, form an

effective volume fracture network, and vastly improve the stimulation effect of measures. The successful implementation of this process is of great significance for the exploration of potential and increase efficiency of old wells in horizontal wells with thin oil.

(2) For reservoirs with strong heterogeneity, it is difficult for limited entry fracturing to ensure that multiple cracks open at the same time. By reducing the displacement of construction and chemical temporary plugging fracturing, the degree of reservoir reconstruction can be improved and the difficulty of construction can be reduced.

(3) For the reason of the current situation of poor conventional fracturing in low-porosity, low-permeability and low-pressure reservoirs in the old area, the concept of “stimulated reservoir volume fracturing” transformation of horizontal wells was adopted, and the temporary plugging volume fracturing was adopted to realize the development of the confirmed but hard to exploit reserves in the old areas.

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