Research on fracture trend of repeated fracturing

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Abstract: The fracture trend of repeated fracturing is directly related to the effect of repeated fracturing and whether it can effectively expand the swept volume. In this paper, a large-scale hydraulic fracturing process simulation device is used to conduct laboratory experiments on fractured reservoirs to study the initiation and extension of repeated fracturing fractures under different stress states. The experimental results show that new fractures are easy to extend from the natural fractures near the wellbore, and the initiation pressure of the secondary fracturing is reduced due to the inducing effect of the initial fractures. The conclusion has a certain guiding function for the prediction of repeated fracturing fracture propagation in field fractured reservoirs, and it is of great significance for fracturing construction.

1. Introduction
Repeated fracturing has been widely used as the main measure to increase oilfield production [1-2]. Repeated fracturing of fractured reservoirs has the influence of geological factors such as in-situ stress, initial fractures, natural fractures. as well as the influence of engineering factors such as construction displacement, fracturing fluid viscosity, perforation characteristics. The study of repeated fracturing processes is more complicated [3-5]. For the first time in this paper, by means of experiments, considering the existence of natural fractures around the wellbore, the influence of factors such as in-situ stress changes and initial fractures on the formation of repeated fracturing is studied.

With the continuous improvement of living standards, people's demand for oil is increasing, Nowadays, with the continuous downturn of international oil price, as a key means of reducing cost and increasing efficiency, repeated fracturing has been highly valued by various oil companies. In recent years, refracturing technology has been more and more widely used all over the world. Fracture initiation is not only controlled by in-situ stress field, but also plays a decisive role in the change of temperature field and formation pore pressure field caused by fracturing fluid injection. The existence of initial fractures and the decrease of formation pore pressure will cause the change of in-situ stress field, resulting in the complexity of fracture strike of repeated fracturing. Through the analysis of repeated fracturing technology and the influencing factors of fracturing effect, we can avoid wasting more manpower and material resources in the process of oil well exploitation[6-8]. Using the sample core and the method of indoor repeated fracturing simulation experiment, this paper studies the fracture making mechanism of repeated fracturing, quantifies the possibility and conditions of making new fractures, and creates conditions for predicting the fracture trend or creating new fractures on site. It has important guiding significance for selecting the time of repeated fracturing, optimizing the fracturing design and improving the effect of repeated fracturing[9-10].
2. Experimental Equipment and Rock Sample Preparation

2.1. Experimental equipment
This experiment uses a large-scale hydraulic fracturing process simulation device for repeated fracturing experiments. The device includes the following: fracture pressure components, cylindrical rock sample holder, square rock sample holder, and fracturing experiment platform, heating box simulating ground temperature, ring pressure providing system, three-way pressure providing system, pipe valve system, data acquisition and processing system, operation console and other parts.

The components of fracture pressure, cylindrical rock sample holder, square rock sample holder and fracturing experimental platform in the list of devices involved are mainly used to provide operating platform and orientation fixation for the samples held. The heating box simulating ground temperature is mainly used to simulate the temperature environment of samples underground. The environmental pressure supply system and three-way pressure supply system are used to simulate and provide different stress conditions, The pipe valve system, data acquisition and processing system and console are mainly used for the operation environment and subsequent data acquisition, analysis and processing.

Among them, hydraulic fracturing process simulation test device parameters: maximum fracturing pressure: 65MPa; axle load pressure 40MPa; square hydraulic fracturing model specification: 500 × 500 × 800mm; fracturing fluid type: water, oil.

2.2. Rock sample preparation
Mixing cement and quartz sand in a ratio of 1:1, mixing concrete samples with a size of 500 × 500 × 800mm, wellbore length 200mm, 90° phase angle perforation, a total of 16 holes, natural cracks less than 80 × 80mm plastic flakes.

2.3. Experimental design
A total of 4 rock samples (1# and 2# rock samples are used as test equipment) are designed for the experiment. Under different stress field conditions, the influence of the existence of natural fractures on repeated fracturing is considered. The designed stress conditions and schemes are as follows.
Tab.1 Design stress conditions and schemes

| No. | Primary fracturing | Secondary fracturing | Other conditions |
|-----|--------------------|----------------------|------------------|
|     | $\sigma_x$/MPa | $\sigma_y$/MPa | $\sigma_z$/MPa | $\sigma_x$/MPa | $\sigma_y$/MPa | $\sigma_z$/MPa |
| 3#  | 1 | 3 | 4 | 3 | 1 | 4 | Initial crack |
| 4#  | 2 | 3 | 4 | 4 | 4 | 4 | Initial crack + natural crack |
| 5#  | 2 | 4 | 3 | 2 | 2 | 2 | Initial crack + natural crack |
| 6#  | 1 | 3 | 4 | 2 | 2 | 2 | Initial crack + natural crack |

2.4 Experimental purpose
Re fracturing technology is an important measure for increasing production and efficiency of low-permeability oil fields and unconventional oil and gas reservoirs. By opening the oil and gas channel of the reservoir by repressurization, higher production can be obtained. A large-scale hydraulic fracturing process simulation device is used to conduct indoor experiments on fractured reservoirs to study the initiation and extension of re fracturing fractures under different stress states, It provides important technical measures for the next development of low permeability reservoir, It also provides a reliable guarantee for the sustainable development of low permeability oil fields, the development direction of refracturing technology in low permeability oilfield is defined[11-13].

3. Experimental Results and Analysis
This experiment investigates the propagation of secondary fracturing fractures under different stress conditions.

In the initial fracturing of 3# rock sample, when the pressure rises to 6MPa, the rock sample ruptures, resulting in a vertical fracture perpendicular to the minimum principal stress, changing the direction of the maximum and minimum principal stress (the size remains unchanged), and performing secondary fracturing. The shaft turned far away, the fracture pressure was only 4.3 MPa, and the two fractures produced in the 3# experiment were perpendicular to each other.

It can be seen that under the condition of 2MPa experimental in-situ stress difference, the secondary fracturing fractures extend and turn along the initial fractures, and the fracture pressure of the secondary fracturing is lower than the pressure of the primary fracturing.

According to the experimental design, considering the existence of natural fractures, when the fracture fracturing is 6.8 MPa, after the initial experiment, the stress condition is changed to 4 MPa, and the second fracturing is performed. When the pressure rises to 2.1 MPa, That is, the pressure drop occurs, and the secondary fracturing fracture does not extend along the natural fracture, but along the primary fracture. The extension pressure of the secondary fracturing is less than 4MPa, indicating that the initial fracturing fractures are not closed.

The 5# rock sample experiment is different from the 4# rock sample in that the direction of the maximum principal stress of the initial fracturing is changed (the size is unchanged), the stress of the secondary fracturing is reduced, and the three principal stresses of the secondary fracturing are all 2MPa. The secondary fracturing fractures do not extend along the initial fracturing fractures, but extend toward the preset natural fractures, indicating that the magnitude of the principal stress will affect the extension of repeated fracturing in the fractured reservoir, and the formation with high stress will follow the original fracture. The cracks extend, and the formation with low stress will extend along the natural cracks.

Comparing the experimental conditions of the 5# rock sample and the 6# rock sample, the stress difference of the 6# rock sample is 2MPa, and the stress difference greater than the 5# rock sample is 1MPa. It extends along the natural fractures, so the stress difference of the primary fracturing and the closed fracturing will be important factors that affect the trend of the secondary fracturing. The stress
difference is large, the stress turning around the wellbore is small, and at the same time, due to the small closing stress, it will affect the closure of the primary fracturing fractures, causing the secondary fracturing fractures to extend along the initial fracturing fractures.

4. Conclusion
Based on the results and discussions presented above, the conclusions are obtained as below:

(1) Repeated fracturing technology is a key mean to increase single well production, ensure stable production and improve economic efficiency in low permeability oilfield. The primary fracturing stress difference and closed fracturing are important factors affecting the secondary fracturing trend.

(2) Under the condition of low in-situ stress difference in fractured reservoirs, the magnitude of the principal stress determines the direction of the secondary fracturing fractures. The greater the principal stress, the better the closure of natural fractures, and it is not easy to turn along the natural fractures.

(3) High stress difference and low closure stress will make it difficult to divert the stress field near the wellbore. At the same time, the initial fracture closure is poor and natural fractures are difficult to open. The in-situ stress difference is small, and under the condition of high closure stress, the secondary fracturing fracture is easy to extend from the natural fractures near the wellbore.

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