Research and application of full electronic control testing technology for chemical flooding in Daqing Oilfield

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Abstract—chemical flooding and separate injection has entered the stage of large-scale popularization and application. With the deepening of development, the number of separate injection wells is increasing year by year, and the test workload is increasing continuously. Because the test and adjustment period of chemical flooding wells is shorter than that of water flooding, the test workload and test pressure are further increased. The electric sealing and fishing...
technology is adopted to realize the electric control direct reading in the whole process of sealing, bailing and adjustment of chemical flooding wells, and the efficiency of measurement and adjustment is further improved. This paper introduces the process principle, technical characteristics and application effect of electric sealing and fishing technology of chemical drive. Fund supported projects: National Science and technology major project 2016zx05054 "Daqing placanticline extra high water cut oilfield EOR demonstration project".

1. Introduction
At present, the annual output of tertiary oil recovery technology in Daqing Oilfield has reached more than 10 million tons. Chemical flooding is the main technical means of tertiary oil recovery, and has entered the stage of scale application. In the process of chemical flooding, due to the serious heterogeneity of the reservoir, if the general injection method is adopted, the chemical fluid mainly enters the high permeability layer, and the liquid absorption capacity of the reservoir is high, while the low permeability reservoir, affected by the interlayer contradiction, has a low production degree, which affects the development effect of chemical flooding. These factors require that separate layer production must be adopted for chemical flooding in Daqing Oilfield[1]-[4].

2. The Proposal Of Full Electronic Control Test Technology
At present, the separate layer injection technology of Daqing Oilfield is gradually mature and matched. With the deepening of development, the number of separate injection wells and intervals increases year by year, and the annual test and adjustment workload increases year by year. However, the existing conventional testing technology takes a long time to test a single well, so the test and adjustment efficiency needs to be further improved.

In view of this problem, the electric direct reading measurement and adjustment technology has been developed in the early stage, which can complete the continuous measurement and adjustment of stratified flow rate at one time, which greatly improves the efficiency of measurement and adjustment. However, the supporting sealing and fishing technology still adopts the steel wire delivery mode, which is verified by ground observation and playback. The process is not intuitive and inefficient, and can not meet the requirements of normal fishing with small clamping distance, and the process adaptability is poor. It is necessary to study the electric fishing and sealing instrument to improve the test efficiency, so as to realize the full electronic control test[5][6].

3. Electric Sealing and Fishing Technology of Chemical Drive

3.1. Electric sealing Technology
The sealing test method of layered injection wells in oilfield is mainly to separate the formation pressure from the string pressure by controlling the sealing test bag of downhole electric sealing instrument on the ground, and record and analyze the changes of formation pressure and string pressure to determine the current injection allocator and packer sealing tightness Sealing condition.

In the development of the electric sealing instrument, the following problems are mainly considered.

First of all, because the water drive injection allocator is a bridge eccentric injection allocator, the water drive electric sealing tester uses double skin bags to seal the seal layer, and the chemical drive injection allocator is a common eccentric injection allocator without bridge channel. In view of this situation, an electric sealing tester suitable for the eccentric injection allocator of chemical flooding is designed, and the single skin bag is used to seal the seal layer It is located at the upper center of the injection inlet of the common eccentric injector.

Second, the original electric sealing tester is of compression structure, which is basically the same as that of the traditional storage type sealing tester. The rubber bag is mechanically extruded axially and sealed with the circumferential sealing section of the injector to separate the formation pressure from the string pressure completely. The compression sealing isolation method can not be used to detect whether the sealing test bag works normally Monitoring sensors can not determine whether the sealing
Bag is damaged or not and the authenticity of the sealing instrument and injection dispensing device are in place, which reduces the reliability of sealing conclusion. At the same time, in order to ensure the compression sealing effect, the natural outer diameter of the compressed sealing test bag is generally less than the maximum outer diameter of the sealing instrument instrument by 1 mm. After extrusion, the natural outer diameter of the sealing test bag is not easy to shrink, and it will be slightly larger than the outer diameter of the steel body of the downhole sealing instrument, resulting in frequent replacement of the leather bag and low service life.

In order to solve this problem, an expanding electric sealing instrument is developed. The rubber bag is hydraulically expanded and its outer diameter is enlarged, and it is sealed with the sealing section of the injection distributor to isolate the formation pressure from the string pressure. At the same time, a monitoring pressure sensor is added to detect whether the sealing bag is working normally to monitor the internal pressure of the sealing bag. By monitoring the internal pressure of the sealing bag, the sealing quality can be determined, and the credibility of the sealing conclusion will be guaranteed.

In addition, due to the different sealing mechanism, the natural outer diameter of the sealing bag of the expanding electric sealing instrument is less than the maximum outer diameter of the downhole sealing instrument by more than 5mm. After the expansion of the sealing bag, the natural outer diameter of the sealing bag is easier to shrink, so that the natural outer diameter of the sealing bag will not be greater than the outer diameter of the steel body of the downhole sealing instrument, so as to ensure that the electric sealing instrument is not easy to connect when it is up and down in the pipe string wellbore. It can be used for a long time without replacing the sealing bag. It can be used for more than dozens of wells, which greatly reduces the workload of replacing the sealing bag and the cost of consumables.

The whole electric sealing system is mainly composed of electric sealing instrument, ground control box, computer, cable winch, sky / ground pulley block, wellhead blowout preventer, etc. With the on-site wellhead process, chemical flooding injection string, eccentric injection allocator and packer, the expanded electric sealing operation is realized.

![Composition diagram of electric sealing system](image)

Figure 1  composition diagram of electric sealing system

In the process of sealing inspection, the electric sealing instrument carried by the cable enters the downhole polymer flooding or ASP flooding layered injection string through the sky / ground pulley block and wellhead blowout prevention device until it reaches the target sealing layer (eccentric injection allocator).
According to the operation instructions sent by the ground, the downhole electric sealing tester detects the formation pressure, string pressure, bladder pressure, temperature, working position and status information of various functional parts, as well as the cable head voltage and motor current of downhole instruments, and sends the detected downhole sealing process information and data carrier to the ground through single core cable, and the ground computer will receive the downhole sealing verification process The information and data are calculated, analyzed and judged, and displayed in the form of text and coordinate curve, so as to provide comprehensive and intuitive downhole sealing process information for field operators.

The underground electric sealing tester can control various related functions at the same time. The main function control includes the selection and implementation of the support arm's retraction or release or butt joint, the selection and implementation of "setting" or "unsealing" of pressure relief.

The process of sealing test can be carried out from bottom to top or from top to bottom. The field operators can operate and control various functions of the downhole electric sealing tester. Finally, through analyzing the changes of formation pressure and string pressure obtained from the sealing test data, the current sealing condition of injection allocator and packer is determined.

3.2. Electric fishing technology

In the eccentric separate layer injection technology, the wire winch is used to lower the mechanical fishing tool into the eccentric separate layer water injection well to put in or pull out the plug. The mechanical fishing tool can only complete one of the plug in or out of the well at one time, and the plug fishing operation efficiency is low.

In addition, after using the electric direct reading test and adjustment process, the cable winch should be used in the test and adjustment, but when the plug needs to be replaced, the wire winch must be replaced to complete the plug fishing. As a result, the test vehicle must be equipped with cable and steel wire double drum at least, and the investment cost is greatly increased.

Therefore, the research on electric fishing technology is carried out. Compared with water flooding wells, the injection fluid viscosity in chemical flooding wells is high, easy to scale, and the length of throttling element is longer than that of water flooding wells, so the process performance needs to be further improved. An electric fishing instrument suitable for chemical flooding wells is designed and manufactured. Compared with the water drive electric fishing technology, it has the following three improvements: 1. The structure of double fishing arm is designed to realize the operation of "putting in one fishing one" at most. Greatly improve the efficiency of fishing operation. 2. Compared with the water drive electric fishing, the length of the plug that can be put into fishing is doubled; the percussion force of the fishing device is increased by 50%; and the fishing force of the fishing instrument is increased by 30%. 3. The whole bailing process is completed by the mechanical action of the instrument itself, and the cable is no longer stressed to avoid damage to the cable due to excessive force; 4. As the electric fishing instrument is put in and the plug is pulled out by the cable winch, the construction team adopting the electric testing and adjusting technology does not need to be equipped with cable and steel wire double drum test vehicle at the same time, so as to reduce the investment cost.

The whole set of electric fishing system is mainly composed of electric fishing instrument, ground control box, supporting control program and supporting power supply (220 VAC), cable winch, overhead / ground pulley block, wellhead blowout preventer, etc. In the process of "one string injection" and "one string injection" operation, the "one string injection" process can be realized.
In the process of putting in and fishing, the electric fishing instrument carried by the cable enters the downhole chemical flooding layered injection string through the sky / ground pulley block and wellhead blowout prevention device until it reaches the target fishing layer (eccentric injection allocator). The operation instructions sent by the ground can detect various functional states, cable head voltage, motor current, support arm movement displacement, underground temperature, etc., and return the detected information and data to the ground. The ground computer will calculate and analyze the received information and data, and display them in the form of text and coordinate curve, so as to provide complete information for field operators It can provide intuitionistic information about the process of downhole fishing.

The field operators control the retraction or release of the boom, the function of throwing and fishing, the number of times of dropping and striking, the positive or reverse guidance of the guide claw, the upward or downward movement of the dropping off support arm, and the upward or downward movement of the bailing out support arm, etc.

Because the whole process is the mechanical action of the electric fishing instrument in static state, the process does not have the minimum stroke distance limit required by conventional fishing technology, which can meet the needs of small clamping distance layered fishing, and the process performance is further improved.

4. Field Test
Field tests of 34 wells have been carried out in the chemical flooding block of Daqing Oilfield. Among them, 20 wells were tested by electric sealing technology, and the success rate of one-time sealing was 100%. The whole well sealing test time of three layers was less than 1 hour without secondary sealing. The efficiency of unsealed wells was 35% higher than that of conventional sealing test. The success rate of interval bailing was 93.3% in 14 wells with electric bailing technology, which was 30% higher than that of conventional sealing.

5. Conclusion and Understanding
(1) The electric sealing technology can realize on-line judgment of sealing test results without ground playback. When the packer is not sealed, there is no need for secondary verification, so the sealing efficiency is further improved.

(2) The electric fishing technology can realize two actions of "one operation and one fishing" when running down the well at one time. The results of the operation can be read directly on the ground, which
can effectively improve the fishing efficiency; the cable can not bear the load during the whole fishing process, which can effectively protect the cable; there is no offset in the process of fishing, which can meet the needs of layered injection with small spacing.

The research and development of chemical drive electric sealing and fishing technology can be compatible with the vehicle and equipment supporting the electric direct reading test and adjustment technology which has been promoted in the early stage. It also solves the problem that the electric direct reading technology needs to be equipped with cable and steel wire double drum testing vehicle at the same time, which increases the investment cost, makes the matching test technology of chemical flooding wells enter the era of electrification from the traditional mechanical era, greatly improves the test efficiency and reduces the construction cost.

Reference

[1] Li Haicheng. Status quo of polymer flooding separate injection technology in Daqing Oilfield [J]. Petroleum and natural gas geology, 2012, 33 (2): 296-301.

[2] Gao Guanglei, Yang Hui, Li Haicheng, et al. Status of polymer flooding separate injection process [J]. Oil production engineering, 2012, 1 (2): 1-4.

[3] Pei Xiaohan, Duan Hong, Cui Haiqing, et al. Eccentric separate injection technology for polymer flooding[J]. Daqing Petroleum Geology and development, 2006, 25 (5): 68-69, 73.

[4] Li Jianyun. Research and application of multi-layer separate quality and partial pressure injection technology for polymer flooding [J]. Inner Mongolia Petrochemical, 2010, (1): 130-132.

[5] Wang Jing, Zheng Qinglong, Gao Zhentao, Hu Jianlin, Shi Xiangyang, Chen ya, pan Jingli, development and application of a new layered water injection measurement and adjustment integrated system[J]. petroleum pipe and instrument, 2018, 4 (3): 18-21.

[6] Zhang Guangchao, development of electric fishing tool for eccentric stratified water injection well plug[J]., petroleum field machinery, 2016, 45 (7): 45-47.