Analysis on the effect of direct reading seal checking instrument in seal checking

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Abstract. The advantages and disadvantages of common sealing methods are analyzed. Aiming at the low sealing rate of bridge type eccentric distribution pipe string packer in Daqing Oilfield, this paper starts with the structure of bridge eccentric distribution pipe string and normal operation and water flow direction during sealing, and combines with the sealing section method sealing principle, discusses the main factors affecting the sealing efficiency of bridge eccentric distribution pipe string. The direct reading sealing tester produced by Xi'an Stan company is optimized. The working principle and sealing process of the sealing tester are analyzed. The switch operation of injection well is optimized. The research results show that: using the direct reading packer, combined with the off on off water injection operation, can verify the sealing performance of the bridge type eccentric distribution pipe string packer, the sealing effect is intuitive, and the test success rate is high.

Keywords: Seal checking; bridge eccentric water distributor; sealing section; direct reading sealing instrument.

1. Introduction
In the process of multi-layer oilfield development, packer is often used to seal each interval, and separate layer injection is carried out according to the difference of interval. Separate layer water injection can maximize the injection water wave and range and the degree of reservoir production. Therefore, the sealing performance of packer determines the quality of separate layer water injection and oilfield development effect to a certain extent. At present, there are four methods commonly used in oil field, such as water injection casing pressure method, plugging pressure gauge method, sealing section test method and isotope injection profile auxiliary sealing method. Water injection casing pressure method can only verify the packer at the top of distribution pipe string, and its application scope is limited. The plugging pressure gauge method needs to pull out the plug of each layer and put the plugging pressure gauge in order to carry out sealing inspection. During the sealing inspection, the workload is large, and the sealing result is greatly affected by the sealing performance of the O-ring of the plugging pressure gauge, so the sealing method of the plugging pressure gauge is not widely used in the field. The auxiliary sealing method of isotopic water injection profile is greatly affected by injection time, logging time and isotope contamination, so the interpretation results can only be used as auxiliary judgment. Therefore,
the test sealing section method is still the most commonly used packer sealing method in the oilfield. The sealing section method mainly relies on the gravity or hydraulic pressure difference compression on the cup to make it produce lateral deformation, and then seal the water injection channel of the water distributor. When the ground is open close open or close on water is concerned, the upper pressure of the cup does not change with the change of the lower pressure, which proves that the packer in the target zone is sealed. The bridge eccentric water distributor is widely used in major oilfields because of the design of four bridge channels to reduce the inter layer interference in the layered test. However, the test results in recent years show that when the traditional sealing section method is used to verify the sealing performance of the bridge type eccentric distribution pipe string packer, the sealing rate of the packer is very low, even when the operation is just finished, the packer is not sealed. Therefore, we question the applicability of the sealing section method in the sealing test of bridge eccentric distribution pipe string. How to effectively verify the sealing performance of bridge type eccentric distribution pipe string packer has become an urgent problem to be solved.

2. Main problems of packer in bridge eccentric distribution pipe string

2.1. Sealing operation of sealing section method
When the sealing section method is adopted, the test sealing section is first lowered into the wellbore by well testing steel wire. After the sealing section is blocked at the ball seat, the relative depth correction is carried out according to the depth of resistance and the depth of the ball seat in the construction design, and the sealing section is lifted to pass the last grading water device. When the sealing section passes through the water distributor, the cam is cut off and the locating claw is released. After passing through the water distributor for about 2m, the sealing section is slowly lowered. After entering the water distributor, the locating claw of the sealing section is supported on the support of the water distributor. The cup continues to move downward under the action of gravity or hydraulic pressure difference and inertia, resulting in transverse deformation, thus sealing the main channel of the water distributor. According to the specified test time, ground on-off-on or off-on-focus on water. Repeat the above operation when lifting the sealing section through the penultimate graded water separator until the sealing section is checked by the top packer. The software replays the test data of dual channel plugging pressure gauge, and proves that the packer is sealed when the formation pressure of the test section does not change with the change of the tubing pressure (Figures 1-3).
2.2. Structure of bridge eccentric water distributor
It is necessary to understand the bridge seal structure without using the bridge sealing device. The bridge eccentric water distributor is mainly composed of upper joint, connecting sleeve, eccentric hole, plug, main body of working cylinder, support, guide body and lower joint [2]. Among them, there are three kinds of water distribution channels: central channel, eccentric main channel and bridge channel, and there are four bridge channels. During normal water injection, the injected water flows through the main channel of water distributor and four bridge channels at the same time. Part of the water flow (green) flows back from the water outlet of the water distributor and the water nozzle of the plug through the main channel, and then enters the oil layer through the upper overflow hole; the other part of the water flow (blue) flows to the lower water distributor through the bridge channel.

2.3. Main problems in sealing inspection
According to the principle of sealing section method, it is the key to judge the sealing of packer that the pressure difference between the upper and lower parts of the cup is formed when the water is injected on the ground. Although the cup seals the main channel of the water distributor, due to the existence of four bridge channels, there will still be water flow through the water distributor of the test layer. It is difficult to generate pressure difference between the upper and lower parts of the cup during the seal inspection with the open close open method, which leads to the failure of the sealing test. The existence of bridge channel also makes the cup of hydraulic compression sealing section unable to completely seal the main channel of water distributor due to insufficient compression, which leads to sealing failure. Therefore, the key to the sealing test of bridge type eccentric distribution pipe string packer is to seal the main channel of water distributor first, and then to form pressure excitation source at both ends of the cup. From the flow direction of water flowing through the bridge type water distributor, it is still feasible to use the close open close method to check the seal if the main channel of the water distributor can be completely sealed.

3. Working principle of direct reading sealing instrument
In view of the poor sealing reliability of the original gravity compression or hydraulic compression sealing section, Xi'an Stan company has developed a direct reading sealing tester.

3.1. Circuit principle of direct reading sealing tester
The circuit part of the direct reading seal detector adopts modular design, including the main control board, motor and magnetic positioning module, pressure and temperature acquisition module. The function of the main control board is to send codes and receive control instructions. The function of the magnetic positioning module of the motor is to control the motor to send out arm opening and closing actions after receiving the command from the driving circuit; the function of the magnetic positioning
module is to receive the magnetic flux change signal generated when the instrument passes through the wellbore, and the signal is transmitted to the ground after digital analog conversion, and the magnetic positioning curve is drawn by software to facilitate depth correction. The function of pressure and temperature acquisition module is to collect pressure and compensate temperature value.

3.2. Mechanical movement principle of direct reading sealing instrument

The sealing section of the direct reading sealing tester is mainly composed of motor, reducer, coupling, positioning arm, slider, push rod, leather cup, etc.

When the arm is opened, the slider of the constraint positioning arm moves away, and the positioning arm opens; in the opening arm stroke, the slider does not exert thrust on the push rod, which is an empty stroke. After the positioning arm is seated in the water distributor bracket, the motor drives the screw slider, and the slider pushes the push rod to compress the cup, thus sealing the main channel of the water distributor. Arm retraction is the reverse process of opening arm after single-layer sealing inspection (Figures 4 & 5).

![Figure 4. Open arm stroke](image1)

![Figure 5. Setting process](image2)

The direct reading sealing tester can observe the sealing effect in real time through the ground controller. If it is found that the sealing is not sealed, it can be set again to eliminate the sealing failure caused by setting reasons. The motor controls the compression of the cup to ensure that the setting is in place. It can avoid the situation that the mechanical seal section is not set in place by gravity, and the hydraulic compression seal section is not set tightly due to the pressure difference between the upper and lower cups. The pre pressure relief channel is designed to balance the oil pressure and casing pressure before unsealing, which can reduce the pressure on the cup, reduce the wear of the cup and prolong the life of the cup.

3.3. Sealing process of direct reading sealing instrument

After the direct reading seal detector and single core cable are connected and debugged normally, the magnetic locator of the seal detector is used to test the position of downhole tools. After depth correction, the seal detector is lowered to the upper part of the water distributor of the target layer to be sealed. After the command is sent by the ground control system, the motor drives the drive shaft to rotate to release the positioning arm. After the positioning arm is seated in the water distributor bracket, the motor drives the transmission shaft to rotate and release the positioning arm. The motor continues to rotate so that the upper and lower cups of the sealing section continue to compress and expand, thus completely sealing the inner wall of the bridge eccentric water distributor. In this case, the surface data acquisition and processing system can be used to observe the sealing condition of underground in real time. After
the sealing inspection is completed, the ground sends out the command, the motor reverses the cup to withdraw to realize the unsealing, and the motor continues to rotate to retract the positioning arm, and turns to the next layer for sealing inspection.

4. Application effect evaluation

Well a was converted to injection in February 2016. The combined string of bridge eccentric water distributor and y341-114 washable well packer was used for water injection, which is a three-stage and three-stage water distribution structure. The injection volume is 40m$^3$/D, the injection pressure is 10.95mpa, and the pump pressure is 15.5mpa. In 2017, the sealing test of ordinary sealing section failed for the first time, but it was successfully verified by using the direct reading sealing instrument of Xi'an Stan company and cooperating with the close open close method. From the sealing test curve, it can be seen that the formation pressure does not change with the change of tubing pressure when the surface is closed, opened and focused on water, which indicates that the sealing performance of each packer is good, and the formation pressure has not been greatly reduced in the process of sealing, indicating that the water absorption capacity of the well is general. A large number of sealing tests show that when the main channel of water distributor is sealed by direct reading sealing instrument, the formation pressure will drop rapidly when the water absorption is large. The non synchronous change of formation pressure curve and oil pipe pressure curve can be observed on the surface operation system, and the packer sealing can be proved without the close on close operation. The surface operating system of the direct reading sealing tester makes the sealing process more intuitive, convenient for observing the sealing condition of the sealing section in the well, convenient for adjusting the injection pressure, and has high sealing efficiency (Figure 6).

5. Conclusion

(1) When the gravity compression or hydraulic compression seal section is used to set the bridge eccentric water distributor, the normal overflow of the bridge channel leads to the failure of sealing the main channel of the water distributor by the cup. The open close open or close on attention water operation excitation effect fails, which leads to the failure of sealing test.

(2) When the gravity compression or hydraulic compression seal section is used to set the bridge eccentric water distributor, the normal water flow of the bridge channel leads to the failure of sealing the main channel of the bridge type eccentric water distributor. The open close open or close on attention water operation excitation effect is invalid, resulting in sealing failure. The main channel of bridge eccentric water distributor can be completely sealed by using direct reading sealing instrument. The ground operation system can directly observe the well during operation the sealing process of the lower sealing section is convenient to adjust the water injection pressure.

(3) The packer of bridge eccentric distribution pipe string can be checked by using direct reading packer with close on water operation, and the efficiency is high. When the water absorption of the interval is high, it is not necessary to carry out the operation of "close on" and "pay attention to water". 

Figure 6. A well inspection curves
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