

Development and Application of Subdivision Water Injection Technology in Gudong Oil Production Plant

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Abstract

The conventional eccentric water injection string is generally used in multi-stage separate injection wells, and the equal pressure drop test method is adopted, and the water volume calculation method is adopted, and the average test period of a single well is 8 days. With the concept of reliability design, the working reliability of separate injection string was strengthened, and the measures of separate injections, subdivision injections, interval recombination and pipe inspection and redistribution were implemented on site. The average number of separate injection layers per single well in sandstone reservoir increased from 2.9 to 3.5, and the average number of separate injection layers per single well in main sandstone reservoir increased steadily from 3.0 to 3.8. At the same time, the linkage technology of bridge eccentric separate injection and measurement and adjustment is gradually popularized, and the average test period of single well is shortened from 8 days to 2 days.

Keywords

Subdivision water injection, Water distribution of sealing cutter, Water injection string, Layered water injection

Introduction

Water injection development has always been an important technical means to improve the development effect of oil fields, which can effectively maintain formation pressure and realize the displacement of crude oil [1]. For thin layers and reservoirs with multiple sets of reservoirs in the vertical direction, it brings certain difficulties to the implementation of water injection technology, especially for layered water injections, and it is necessary to adjust the water injection of each layer. For layered water injections, a lot of research work has been carried out at home and abroad, and the research and development of the technological structure of layered water injection string is still in progress [2].

From 1988 to 2009, in order to meet the development needs, Shengli Oilfield successively studied and applied the techniques of casing separate injection, backwashing, fishing concentric

separate injection and common eccentric separate injection string, and finally developed the GY341-114(II) packer with common eccentric string as the separate injection string of 51/2" casing water well, and the GY341-148(III) packer with common eccentric string as the 7". At the same time, collecting test tools and lifting fishing devices were introduced to fish the plug and replace the water nozzle. The flow rate was tested by decreasing method, and the sealing inspection technology of double-card pressure gauge was developed to seal the packer. For 11 years, the separate injection string and testing technology have been used [3].

From 2010 to now, to improve the reliability of separate injection string and the level of fine injection technology, GY341 packer has been continuously improved, and 7" casing well has been equipped with anti-bending technology, which has basically solved the problem of string bending; In

recent two years, the number of injection layers and the efficiency of measurement and adjustment have been improved by introducing the bridge eccentric injection and measurement and adjustment linkage testing technology.

Due to the influence of research and development time and technology research and development cycle, the technology of step-by-step unsealing and separate injection string is still in the experimental stage. There are 130 eccentric bridges, accounting for 59.9% of eccentric separate injection wells, and 87 eccentric bridges, accounting for 40.1% of eccentric separate injection wells [4].

There are 114 separate injection wells with oil casing (including 32 profile control wells and 25 buried hills), accounting for 34.4% of the separate injection wells. In the test, according to the characteristics of condensate oil and directional wells, the non-concentration measurement and adjustment linkage instrument and equipment of double flowmeter are introduced, the single-layer water quantity is calculated by difference subtraction test, and the sealing condition of packer is judged by double-card manometer and oxygen activation test.

Separate injection string technology

New type tubular string expansion compensator

The pressure difference of the original compensator is 25MPa, the compensation distance is 0.3-1m, and it is released at one time, so the resistance to midway resistance is poor; After release, the inner tube slides out of the outer tube working barrel relative to the outer tube, which is easy to be eroded by external well fluid and has poor sealing reliability (Figure 1). The pressure difference of the new pipe string expansion compensator is 30MPa, the compensation distance is 0.3-1m, and it is released for the second time, so it has strong resistance in the middle [5].

The inner tube slides relatively in the outer tube and does not contact the external fluid, so the sealing reliability is good (Figure 1). Consequently, the new pipe string expansion compensator provides a

more stable and reliable solution for long-term well operation.

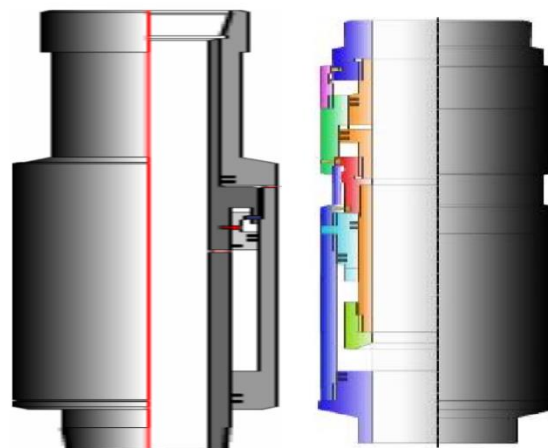


Figure 1. Pipe string compensator.
(left originally used; right: new type).

Double-acting bridge tee

During operation, oil slick enters the pipe, which affects the test (Figure 2, left). The adoption of the new ball seat can not only ensure the hydraulic setting of the packer but also prevent the floating oil from entering the tubing when the operating tubing goes down well, thus ensuring the smooth test (Figure 2, right).

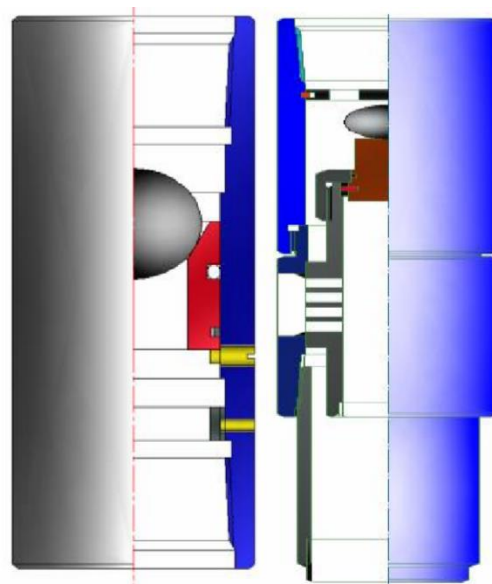


Figure 2. Tee.
(left originally used; right: new type).

Bridge eccentric water distributor improvement

Φ20 eccentric hole adopts blind hole and is lengthened, so that the injected water enters the

plug filter screen from the side instead of from the bottom, which reduces the probability that the plug filter screen is blocked by impurities.

The channel between the eccentric hole and the completely compatible with both direct reading and storage measuring instruments [6].

Forced unsealing packers

The original setting seal is a double-cylinder piston setting seal, which has a large setting force. After the rubber cylinder is compacted, the friction between the rubber cylinder and the casing is large, which makes it impossible to open the lock sleeve and lead to unsealing. A forced unsealing mechanism is added to the new packer, which improves the unsealing reliability of the packer. The setting is a single cylinder setting with moderate sealing force. When lifting and unsealing, the locking sleeve is "pried open" by the forced unsealing block, which improves the unsealing reliability.

Unseal the packer step by step

The pressure relief balance mechanism is adopted, and the upper and lower central pipes are designed in sections to realize gradual unsealing and reduce unsealing load. The whole unsealing mode of the pipe string was changed, and the unsealing was realized step by step, reducing the unsealing load (Figure 3).

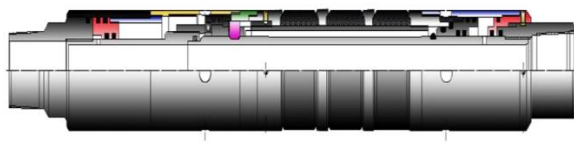


Figure 3. New pressure relief balanced threadless packer.

Improvement of backwashing and unsealing packer

The original K344 packer has a low sealing pressure difference of 12 MPa; Anti-creep performance is low, and water channeling occurs after injection is stopped. A new type of K344 packer has been adopted. The improvement lies in the backwashing valve and liquid inlet valve, which have high sealing pressure of 25MPa and reliable unsealing. The

main body adopts the downward oblique drilling design; Under the condition of keeping the total length of the main body unchanged, the lower sealing surface is moved down by 10mm, which is principle of setting seal is compression type, and the rubber injection cylinder does not retract after stopping, so it is not easy for water channeling (Figure 4).



Figure 4. New K344 packer.

Balance packer and special ball seat

The balance packer is placed at the bottom of the string, so that the string is always in tension; Special ball seat realizes packer setting and normal backwashing [7-9]. When the operation tubing goes down the well, no liquid is fed, and the lateral vertical channel ensures the packer to set, and then the ball seat is pressed down to communicate with the oil casing to ensure normal well washing.

Separate injection string technology research and development

Design concept

Separate injection technology can only achieve a limited subdivision at the current technical level, and higher requirements can only be solved by adjusting the well pattern of layer series. Separate injection technology should seek to increase the number of separate injection intervals on the premise of ensuring the reliability of the pipe string. To reduce the occurrence of downhole string failure, the interval that is prone to bending is selected by stages and injected separately, and at the same time, the water injection is strengthened in the interval of the same layer adjacent to the water injection well. Using differential pressure water injections, based on the pressure data of the monitored interval, weak water injection was carried out for the previous zero injection interval [10].

The reliability of separate injection strings is

affected by interlayer pressure difference, dynamic operation, well running time, separate injection allocation and string performance, so the basis of separate layers, the number of intervals and the principle of separate injection allocation should be determined [11]. The interlayer has good extensibility and stability, and the thickness is above 1.5m: The number of small layers in the interval is controlled within 10, the thickness of sandstone in the interval is within 15m, and the coefficient of variation of permeability is less than 0.7; Permeability ratio in interval is not greater than 5; No "0" injection allocation is allowed in each injection interval.

Backwashing unsealed layered water injection string

Structure: It is composed of an expandable packer and bridge eccentric water distributor, as shown in Figure 5. The technical requirements are as follows: the completion depth of pipe string should be about 10m below the oil layer; The pressure loss of the water nozzle of the water distributor must be greater than 0.7MPa to ensure that the packer is set. After normal well washing, the casing must be depressurized and the tubing must be injected to ensure re-setting; The packer sticking point shall be kept away from the hole, causing coupling and casing damage, otherwise it will be difficult to seal or unseal. Generally, the distance between eccentric water distributors should not be less than 8m [12-15]. **Features:** after backwashing, the rubber tube retracts and unseals, which is convenient to increase the number of stages; Bridge-type offset, convenient for fishing and testing. The reliability of

zonal water injections is effectively enhanced, and the risk of operational accidents is reduced. In addition, the flexible structure is designed to improve adaptability to complex well conditions, thereby prolonging the service life of downhole tools.

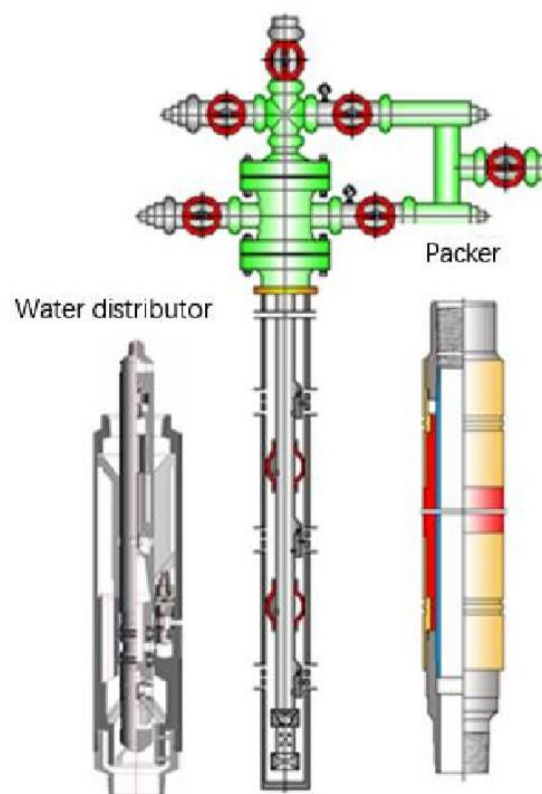


Figure 5. Schematic diagram of backwashing and unsealing a layered water injection string.

Application of backwashing unsealed layered water injection string

The test has been applied for 7 wells, and the average number of separate injection layers has increased from 3.3 to 5.5, as shown in Table 1.

Table 1. Application of backwashing and unsealing the layered water injection string.

Serial number	Pound sign	Sub-note level		Unsealing load	
		Before implementation	After implementation	Before implementation	After implementation
1	J61-17	Three levels and three floors	Three levels and four floors	32 tons	26 tons
2	J19-35	Four levels and five floors	Four levels and five floors	40 tons	33 tons
3	J65-029	Three levels and three floors	Three levels and three floors	45 tons	36 tons

Serial number	Pound sign	Sub-note level		Unsealing load	
		Before implementation	After implementation	Before implementation	After implementation
4	J67-257	Three levels and four floors	Seven levels and eight floors	44 tons	Leak-sealing pending inspection
5	J63-35	Two levels and two floors	Five levels and six floors	40 tons	34 tons
6	J20-32	Two levels and three floors	Five levels and six floors	31 tons	25 tons
7	J31-43	Three levels and three floors	Four levels and five floors	40 tons	34 tons

Conclusion

Subdivision water injection is a systematic project, which involves the technical level of pipe string, design and construction, judgment and treatment of problems, information feedback, etc. All links are coordinated smoothly, which is conducive to improving the overall level.

At the same time, it is also necessary to carry out the fault analysis and judgment research of separate injection wells in time. The water injection packer and water distributor work for a long time in the high temperature and high-pressure environment underground. Due to their poor downhole conditions and environment and the influence of water injection pressure fluctuation, the separate injection string may have problems at any time, resulting in the failure of separate injections. Therefore, it is necessary to determine the situation of separate injections underground in time and provide decision-making basis for measures.

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Conflicts of Interest

The authors declare no conflict of interest.

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