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Research on Parallel Reservoir Perforation Technology

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Research on Parallel Reservoir Perforation Technology

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Abstract. The parallel reservoir perforating technology enables each shot hole in the gun to be fired in a direction parallel to the reservoir at a set angle, realizing a new technique in which the perforating projectile and the reservoir are parallel. The technology can be combined with the azimuth perforating technology. For the oblique angle of the reservoir and the wellbore, the oil pipe conveying type azimuth perforating technology, the inclined well self-orientation perforating technology and the modular cable perforating technology can be used for construction. The technology can effectively reduce the fracture pressure of reservoir construction, improve the productivity of medium and low permeability reservoir oil wells, and meet the needs of low permeability, thin poor layer and special well development and transformation.

Key words: Parallel reservoir, orientation, inclined formation.

1. Introduction

Perforation completion, which is an important part of the oil and gas field exploration and development process, is like a “footstep” on the football field, which plays a vital role in the exploration and development of oil fields. At present, the jet directions of all the perforators are perpendicular to the gun body, and the well axes of some wells are oblique to the oil and gas stratum. The direction of the jet cannot be parallel with the reservoir. Especially for the construction of thin wells, the raft layer is very likely to occur, which affects the perforation construction effect. In recent years, through theoretical research, it has developed a perforating technology that enables each shot hole in the gun to be projected in a direction parallel to the reservoir at a set angle, thereby achieving parallel reservoir perforation and improving the perforation construction effect. Obtained obvious yield increase effects. Through theoretical calculations and field tests, the perforating technology has a jet direction parallel to the reservoir, which can effectively reduce the fracture pressure of the reservoir construction. Meet the needs of oilfield low permeability, thin poor layer and special well development and transformation.

2. Technical principle and characteristics

2.1. Technical principle

The parallel reservoir perforating technology enables the perforating technology that each shot hole in the gun can be shot in parallel with the reservoir by the orientation technique according to the set angle. The technology can avoid the occurrence of strontium layer, can effectively reduce the fracture pressure



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of reservoir construction, and improve the productivity of medium and low permeability reservoir oil wells [1, 2].

2.2. Technical characteristics

(1) changing the traditional solid-frame method of the elastic frame so that part of the perforating projectile jet is not perpendicular to the gun body;

(2) Does not affect the penetration performance and phase angle of the perforator, since the perforating bullet is not perpendicular to the gun body, the hole density becomes smaller;

(3) It can be easily installed without special installation process, which is basically the same as the conventional perforating gun installation process;

(4) can be organically combined with the orientation technology;

3. Parallel reservoir perforator design

Parallel reservoir perforating technology perforator is different from conventional perforator and requires improvements in the design and processing of perforating gun body and spring frame structures. During the conventional perforation completion construction, the direction of the perforating projectile is always perpendicular to the perforating gun body, and the perforator is down the wellbore, and the perforation holes formed in each phase are also perpendicular to the wellbore and the perforating gun body [3]. When the parallel reservoir perforating technique is adopted, part of the perforating bullet is no longer perpendicular to the perforating gun body, and the second is inclined to be assembled on the elastic frame. The direction of the jet after the perforation is parallel to the reservoir (see Figure 1). Since the geological conditions of each well are different, it is necessary to “tailor-made” the perforator according to the inclination angle and the inclined orientation of the formation.

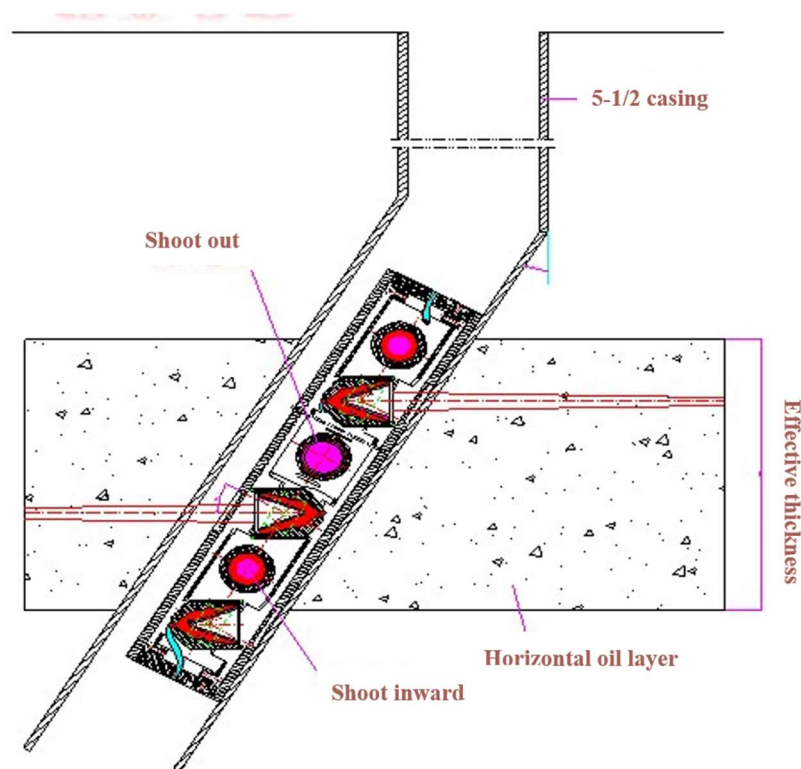


Figure 1. Parallel reservoir perforation technology jet angle effect diagram.

3.1. Fixed jet angle perforator

According to the oblique angle of the wellbore and the reservoir, the elastic frame suitable for the perforation angle of the single well is directly designed and processed, and the perforation angle is not adjustable. The structure is shown in Fig. 2.



Figure 2. Structure diagram of fixed jet angle perforator.

3.2. Adjustable jet angle perforator

The development design has both the "shooting angle" and the vertical projectile structure; the angle adjustment and the vertical projectile hole are half of each in the frame, the odd number of the frame is the angled bullet hole, and the even number is the conventional vertical projectile hole. The first hair-increasing bullet hole is shot inward, and the last one is a vertical bullet hole. The angle range is 0-40° [4].

The angle adjustment tool adjusts the "shot angle" of each shot hole. The tool is buckled on the circular arc surface of the elastic tube, and rotates the perforating bullet below the pointer according to the angle of the pointer disc, so that the small tip on the elastic sleeve is aligned with the pointer on the tool, and then the screwdriver is placed under the pointer disc. Fixing the top wire on the elastic frame at the reserved hole can fix the angle of the perforating projectile and ensure the accuracy of the angle adjustment within $\pm 1^\circ$. The structure is shown in Figure 3.



Figure 3. Adjustable jet angle perforator frame structure.

4. Construction method design

4.1. Straight well construction method design

4.1.1. Construction process principle. The use of tubing conveying type azimuth perforating technology, the process principle is to connect a fixed azimuth sign consistent with the azimuth sign of the azimuth perforator between the azimuth perforator and the oil pipe. After the pipe column is deepened, the pipe will be fixed. The azimuth instrument is docked with the fixed orientation mark in the oil inlet pipe, and then its orientation is measured. After multiple measurements and rotation of the pipe string, the final aperture orientation mark is consistent with the design target orientation, and the instrument is activated and the perforating gun is detonated. construction. See Figure 4 [5].

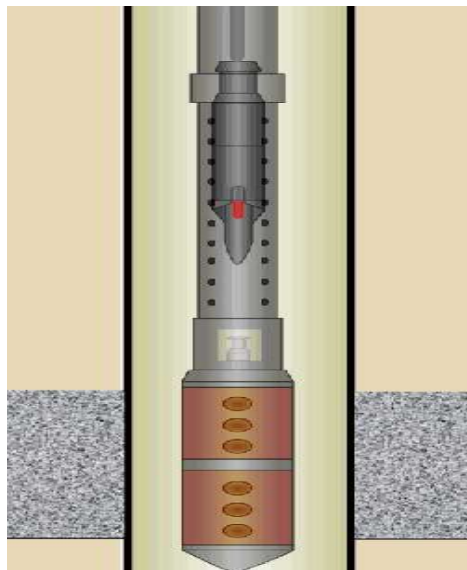


Figure 4. Schematic diagram of tube orientation aperture technology.

4.1.2. Structural composition. The tubing conveying type fixed-direction construction structure includes: parallel reservoir perforator and locator.

4.2. Design of construction method for high-angle well

4.2.1. Construction process principle. When the well inclination is greater than 35° , when the oil pipe conveying type azimuth perforating is adopted, there is a case where the column cannot be rotated for positioning, so the perforating self-orienting oil pipe conveying perforating technology can be adopted, and the technique is in the perforating layer section. Under the condition that the well body has a certain inclination, the perforating gun is equipped with orientation devices at both ends, and a rotary joint is arranged at the top end of the perforator, and the weight of the orientation device and the action of the spring arm and the free rotation of the rotary joint are utilized. The spring arm is aligned with the oblique direction of the wellbore, and the perforating direction of the perforating projectile is adjusted in the direction of the known perforation layer direction and the oblique direction of the well before the lower well, and the perforation column is calibrated to the depth of the well. After that, the perforation can be detonated. It adds orientation and swivel structure, but eliminates the need to measure azimuth and rotate perforated columns with a gyroscope. (See Figure 5)

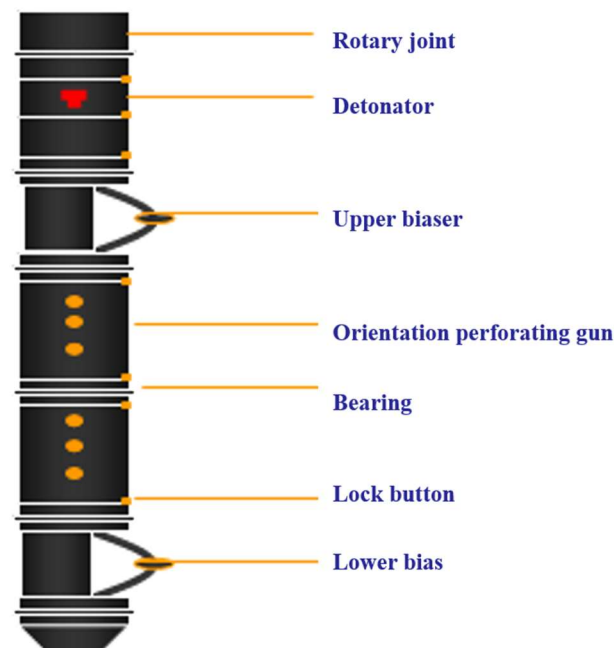


Figure 5. Schematic diagram of self-directed perforating technology in inclined well.

4.2.2. Structural composition. The inclined well self-orientation construction structure comprises: a parallel reservoir perforator, a rotary joint, a detonator, an upper deflector, a lower deflector, a bearing and a locking key.

4.3. Design of multi-slope well construction method

4.3.1. Construction process principle. When the construction well has multiple oblique angles, it is impossible to manually or automatically rotate the pipe string for positioning when using the oil pipe conveying type azimuth perforating and the inclined well self-orientation perforating technology. Therefore, the module gun directional cable perforating process technology is adopted. When the technology is used, the cable gun + depth locator + salvage/release device is first used to lower the module gun supporter to a predetermined depth of the oil layer to be placed on the casing. Using the magnetic injection signal and assisting the resistance curve, determine the exact setting depth of the support. Then, the downhole azimuth gyro inclinometer is used to determine the orientation of the guide on the upper part of the support after the setting, and the aperture orientation is determined to achieve the azimuth perforation. After the depth and orientation are determined, the perforating gun is stepped into the well, and the gun body and the gun body are automatically oriented and docked [6]. It can be detonated by pressure detonation, cable butt detonation and casing rod impact. See Figure 6.

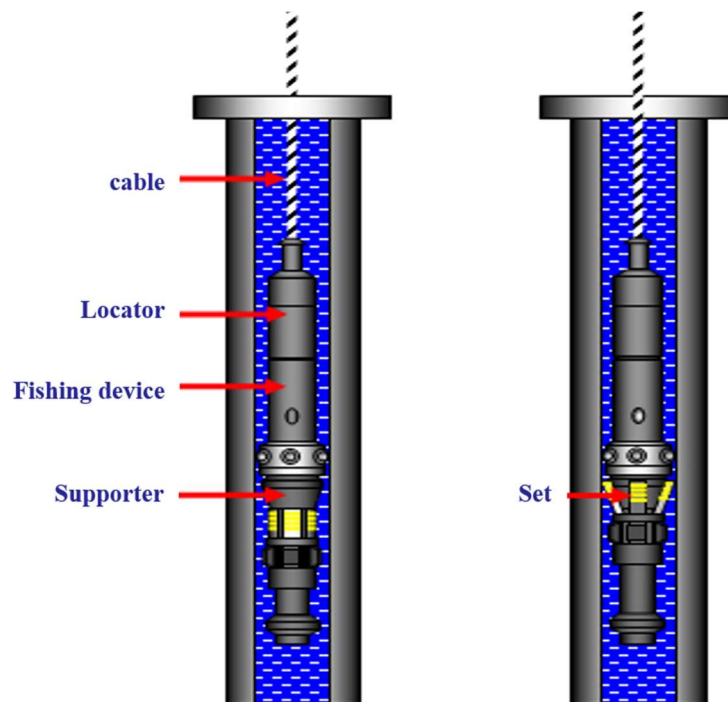


Figure 6. Schematic diagram of module gun directional cable perforation technology.

4.3.2. *Structural composition.* The module gun directional cable perforation construction structure includes: parallel reservoir perforator, detonator, depth directional system, anchor support system, butt and right centering system, salvage release device and multi-channel control system.

5. Application examples

Parallel reservoir perforation technology was used to perform on-site perforation tests of 3 wells and positional measurements were performed to verify the reliability and applicability of parallel reservoir perforating techniques. See Table 1.

Table 1. Test well positioning angle error.

Serial number	Hashtag	Time	Layer	Error (°)	Remarks
1	Huo 3-X4	May 25, 2011	K1n2 layer	9.6	
2	The east of Gulong 386-oblique 396	March 12, 2012	PI-3, layer 1	5.8	Process test
3	La 2- oblique PS2816	April 23, 2012	Layer S3-1, 3, 4	7.7	Process test

6. Conclusion

(1) Realizing parallel reservoir perforation by improving the structure and performance of the perforator, so that the perforating technology can meet the requirements of geological development and achieve the purpose of “precise” perforation;

(2) For different well conditions, different forms of azimuth perforating technology are used for organic combination to achieve precise positioning, so that the jets are injected parallel along the reservoir direction to achieve the parallel reservoir perforation construction effect.

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