Application of multiphase flow fiber optic fluid production profile testing technology in W1 well

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Abstract. In recent years, the number of completions of tight oil horizontal wells in oil field X has increased year by year. Horizontal well fracturing technology has been widely used in the development of tight oil reservoirs in oil field X. However, there are still some technical difficulties in the dynamic monitoring of horizontal wells. Monitoring is mainly for inclined vertical wells, and there are few dynamic monitoring methods and means for horizontal wells. Therefore, the production of each cluster after fracturing in horizontal wells has not been accurately monitored. To obtain the output of each cluster after fracturing in horizontal wells, analyze and evaluate fracturing effects, and guide the preparation of fracturing plans, it is necessary to conduct fiber-optic fluid production profile testing and research. Optical fiber monitoring technology for horizontal wells has developed particularly rapidly in recent years. At present, a relatively mature distributed optical fiber temperature DTS supporting technology has been formed. It is widely used in the monitoring of unconventional reservoirs in some large oil fields abroad, meeting the actual monitoring needs, and has achieved good results. better application effect. This paper expounds the basic principle and well selection principle of horizontal well optical fiber testing, and introduces the knowledge obtained in practical application. It is of great significance to accelerate the application of horizontal well optical fiber monitoring technology in the development of tight oil reservoirs in X oil field, improve the dynamic monitoring of horizontal wells and evaluate the fracturing effect.

Keywords: Output of each cluster of horizontal wells; Fiber Monitoring; Liquid production profile test.

1. Test principle of multiphase flow fiber optic liquid production profile

1.1 Optical fiber monitoring principle

Fiber optic monitoring (DTS) in horizontal wells uses the Raman effect for temperature measurements. A laser sends a pulse of light along the fiber. Some light is reflected back as backscatter, which can be analyzed to separate the backscattered light from the incident pulse. , and filtered into discrete wavelength signals, the speed of light remains constant, and backscattered light measurements per meter of fiber can be obtained.

In Raman scattering, the energy transfer between scattering molecules and photons is related to temperature. When the scattered light appears at a frequency lower than that of the incident light, the scattered photons release energy to the medium in the form of an extra phonon in the interaction. The resulting new spectral signature is called the Stokes band. In the opposite case, scattering increases the frequency and energy is transferred from the medium to the light. This is called anti-Stokes scattering. The anti-Stokes band is more sensitive to temperature than the Stokes band. Both The ratio of the signals is often used for temperature estimation. The Stokes signal with a longer wavelength has a very weak temperature sensitivity, and the backscattered light of the anti-Stokes signal with a shorter wavelength has a strong sensitivity to temperature. The ratio of the anti-Stokes to Stokes signal is proportional to the temperature of the scattering medium. Based on the Raman scattering principle, the scattered light intensity is measured to obtain the temperature distributed along the fiber. The temperature point is located by measuring the time when the backscattered light returns to the starting end. Similar to the radar echo technology, the distributed temperature measurement of the fiber is realized.

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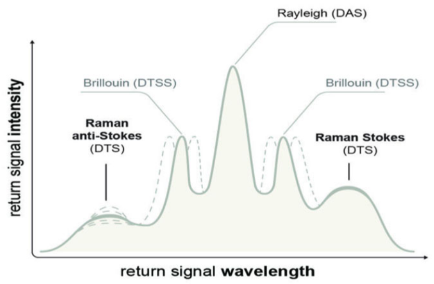

Fig. 1. Inverse discrete spectroscopy

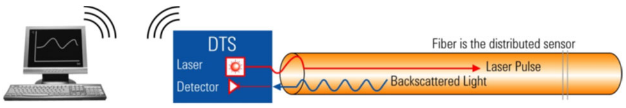

Fig. 2. Schematic diagram of horizontal well fiber test.

2. Application in tight oil horizontal wells

2.1 Test well selection

In order to measure the production of each cluster, comprehensively analyze and evaluate the fracturing effect, Well W1 with a longer horizontal section was selected for testing. Well W1 is located in block Z. The block is located in the east wing of the downdip part of the F nose structure. It is located on the west side of the F nose structure in the Q Sag. It develops fluvial-delta facies deposits. microphase. Main layer FI7 sublayer and dessert layer FI4 sublayer. The coiled tubing fiber optic technology is used to monitor the liquid production profile. By formulating different supporting test systems, the liquid production capacity of a single section (cluster) of horizontal wells under different working systems is monitored to ensure the effective identification of the contribution rate of oil production and water production of each section (cluster). The liquid production capacity of each segment (cluster) was qualitatively analyzed. After the construction is completed, the liquid production capacity of each section (cluster) is quantitatively analyzed, and the oil production and water production status of the subsection (cluster), and the production contribution rate of the section (cluster) are given.
The target layer of Well W1, layer FI7, has a drilling depth of 4670m and a horizontal section of 2472m. 2096m of sandstone were encountered, the sandstone drilling rate was 84.79%, 1974m of oil-bearing sandstone was encountered, and the oil-bearing sandstone was drilled with a drilling rate of 79.85%, including 1637m of oil immersion and 337m of oil spots. The thickness of the target sandstone is 5.0m, the effective thickness is 4.4m, the porosity is 11.7%, and the permeability is 1.2mD. According to the temperature data of 23 surrounding layers, the temperature of Y oil layer is 86.0℃-93.3℃, and the average geothermal gradient is 4.84℃/100m. The formation pressure gradient of Y oil layer in the well area is 0.9~1.08MPa/100m, with an average of 0.97MPa/100m, which is a normal pressure system reservoir.
The first section of the well is perforated by tubing, the second to twenty-seventh sections of cable transmission composite bridge plugs; the casing multi-section and multi-cluster volume fracturing 27 sections and 163 clusters; the average cluster spacing of infill is 15m; Volume 2200m^3, proppant 220-240m^3; Paragraph 10-13, liquid volume 1500m^3, proppant 175m^3; Paragraph 14, volume 1753m^3, proppant 210m^3; Paragraph 17, volume 1044m^3, proppant 105m^3; Paragraph 15-16,18-27 section liquid volume 2000m^3, proppant 240-280m^3; total liquid volume 53468m^3 proppant 6421.8m^3.

2.2 Coiled tubing fiber optic data acquisition

2.2.1 Monitoring feasibility analysis

In order to successfully complete this optical fiber test task, the factors that may lead to logging failure are analyzed as follows:
1) Whether the design and production system can be achieved through the control of the nozzle.
2) The casing-to-coiled tubing cannot reach the target layer due to fracturing.
3) Coiled tubing self-locking caused by bottom hole pressure and wellbore trajectory.
4) During the test, the coiled tubing was stuck due to sand production in the well. Based on the above analysis, the well can be adjusted to design the test production system and meet the test requirements. There is no self-locking during the running of the coiled tubing, the wellbore is in good condition, and there is no risk of encountering resistance caused by casing changes, and the coiled tubing can be run into the test target layer. There is no sand production during single well drainage and adjacent well drainage, and it is judged that there is no sand burial risk during the test.

2.2.2 Monitoring main equipment

Table 1.Horizontal well fiber optic test equipment statistics table

Classification	Heading	Models and Specifications	Amount
Collection equipment	DTS modulation equipment	AP Sensing， DTS N4415A，N4386B 1550nm、1064nm	3piece
	DTS Analysis software	DTS configurator ISP Analysis	3set
	Auxiliary equipment	Optical fiber fusion splicer Optical cable connection protection Connect the fiber optic cable	1set
Ground equipment	Coiled tubing fiber optic equipment	Coiled Tubing Vehicle Coiled Tubing Fiber Optic Coiled Tubing Injection Head	1set
Downhole tools	Storage pressure gauge	Storage pressure gauge	2set

2.2.3 Fiber monitoring situation

After the fiber optic coiled tubing enters the well to the bottom, it is circulated to monitor the ground temperature baseline, and the monitoring time is 6 hours. Carry out the first production system, the monitoring time is 12 hours, and obtain production data to meet the data analysis requirements; carry out the second production system monitoring, the monitoring time is 12 hours, and obtain production data to meet the data analysis requirements; carry out the third production system monitoring, monitoring After 12 hours, the production data was obtained to meet the data analysis requirements; the monitoring was completed; the fiber optic coiled tubing was pulled out of the wellbore; the site was sorted out, and all construction operations ended.

In this well logging, shut-in, 6.35mm nozzle, 7.94mm nozzle, and 9.53mm nozzle production were carried out to monitor the output under the three nozzle production systems. Combining all the data to carry out calibration analysis, quantitatively explain the output of each level under the three production systems. The DTS test method is used to carry out continuous monitoring of the whole wellbore, to complete the interpretation of distributed temperature data, to carry out the correction and interpretation of gas production profiles in all directions and from multiple angles; to carry out comparative analysis of geological engineering parameters.

2.3 Coiled tubing fiber optic test results interpretation

The 6.35mm nozzle has a production rate of about 1.0m^3/h. Figure 3 shows the production contribution percentage of each perforation section in the model (from the heel end to the toe end of the horizontal well, the perforation sections are S27-S14 in sequence). It can be seen that S25 -S27 section has a low contribution to the liquid production, and each section towards the toe end has a relatively high contribution to the liquid production. The specific liquid production contribution percentage of each section is shown in the table.

The 7.94mm nozzle, the production is about 1.26m^3/h Figure 4 shows the production contribution percentage of each perforation section in the model (from the heel to the toe of the horizontal well, the perforation sections are S27-S14 in sequence). It can be seen that the liquid production contribution of S25-S27 sections is low, and the liquid production contribution of each section towards the toe end is relatively high. The specific liquid production contribution percentage of each section is shown in the table.

The 9.53mm nozzle, the output is about 1.48m^3/h. Figure 5 shows the production contribution percentage of each perforation section in the model (from the heel to the toe of the horizontal well, the perforation sections are S27-S14 in sequence). It can be seen that the liquid production contribution of S25-S27 sections is low, and the liquid production contribution of each section towards the toe end is relatively high. The specific liquid production contribution percentage of each section is shown in the table.

It can be seen from the inversion results that under different nozzles, the production contribution ratio of each perforation section is roughly the same. The contribution of S25-S27 stage liquid production is relatively low, and the S15-S16 and S18-S21 stage liquid production contribution is relatively high. The interpretation results of the fluid production contribution of Well W1 are shown in the figure. Under different nozzles, the fluid production contribution of each section is roughly the same. The contribution of S15-S21 is higher, while the contribution of S25-S27 is lower.Under different nozzles, the production contribution ratio of each perforation cluster is roughly the same. 83-88, 93-94, 97-124, 136-137 clusters contributed relatively high liquid production.

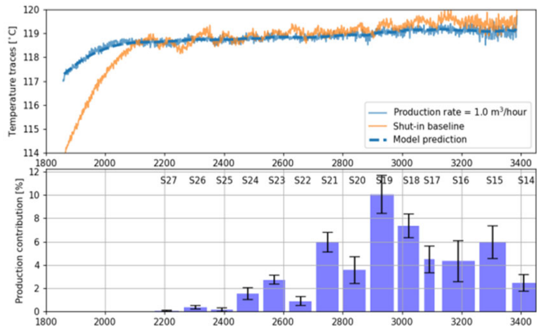

Fig.3.contribution to various sections under the 6.35mm nozzle

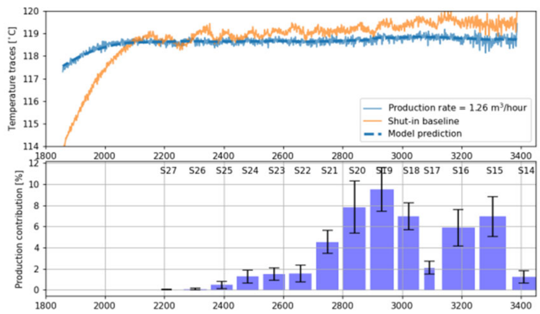

Fig.4.contribution to various sections under the 7.94mm nozzle

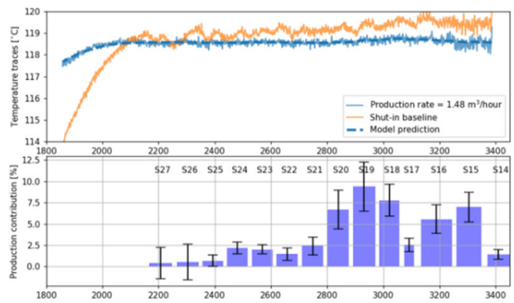

Fig.5. contribution to various sections under the 9.53mm nozzle

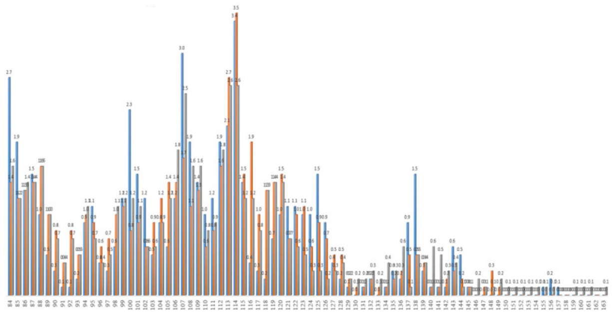

Fig.6.Contribution of each cluster fluid production under different nozzles

6.35mm nozz 7.94mm nozz 9.53mm nozz

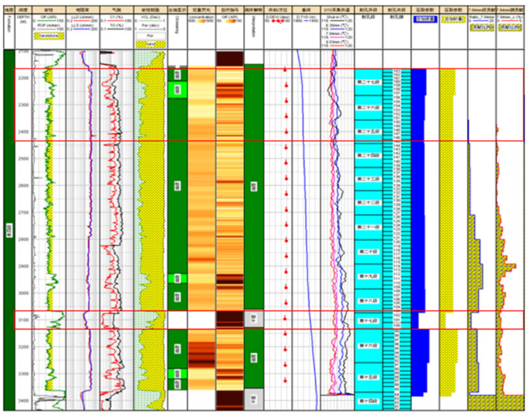

Fig.7.Production liquid contribution

2.4 Comparative analysis of test results and drilling data

Section 1-4 of Well W1 has relatively low natural gamma values and relatively high quantitative fluorescence values. The formation sand bodies are well developed and have good oil content (physical properties). The fiber test results show that they have a high contribution to productivity. The fiber monitoring proves that this section has It is the main oil-producing interval of horizontal wells.

The natural gamma value of the fifth section of Well W1 is relatively low, and the formation sand bodies are developed. The quantitative fluorescence value is lower than that of the 1-4 section, and the oil content (physical property) is worse than that of the 1-4 section. The test results show that the productivity contribution is slightly lower, and the well section can be selected as a re-fracturing in the later stage.

The sixth section of Well W1, the natural gamma value is relatively high, the quantitative fluorescence value is relatively low, and the oil-bearing formation is relatively poor. The test results show that there is basically no contribution to productivity. The later fracturing plan can consider no fracturing or increase in this type of reservoir. Intercluster fracturing.

The seventeenth section of Well W1 has high shale content and has not encountered oil-bearing sandstone. The fracturing process adopts the penetrating fracturing process. Under different nozzles, the fluid production contribution of the S17 section is equivalent to that of the 16th and 19th sections that encountered oil-bearing sandstone. The effect of well penetration fracturing is obvious and effective.

3. Conclusion and understanding

Optical fiber monitoring can continuously record the temperature data of the whole well section. Compared with conventional tracer testing, it can effectively reflect the production of each cluster of oil and water.

Since the starting pressure gradient of the oil phase is higher than that of the water phase, through the comparative analysis of the oil-water ratio in the flowback under different nozzles, amplifying the pressure difference can effectively drive the oil production and reduce the water content.

The well section with low contribution rate of optical fiber monitoring is an important potential interval in the later stage. The horizontal well penetration section has a certain fracturing effect. In the later stage, when the geological understanding is sufficient, the well section can be preferably implemented for the penetration fracture.

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