

Innovation and Practice of Sampling Technique with Precise Controlled Pressure and Speed Regulation

Baisong Tang*, Kun Xu, Hong Ren, Jiang Bian, Chunzhao Tu, Jinting Zhu

Tianjin Branch of Cnooc (China) Co. LTD 300452; Cnooc Energy Development Co. LTD.
Engineering technology Branch, Tianjin 300452, China.

*tangbs@cnooc.com.cn

Abstract

The key to sampling successful in neogene unconsolidated sandstone reservoir is to control the pressure drop reasonably. The usual method is to increase the open area and reduce the pumping speed to reduce the differential pressure of pump as far as possible. However, leakage and sealing are still frequently in the actual sampling process, and the one time success rate and sampling efficiency are relatively low. In this study, by using array acoustic and density logging data, Mohr-coulomb fracture criterion, which applied to calculate the safety production differential pressure and sand production differential pressure in sandstone reservoir, control the stability of flow pressure and reduce the leakage probability. At the same time, the application of isobaric differential pressure with long-stroke precision pump module coordinate broadband speed regulation power joint to control differential pressure pump speed precision, improve the success rate effectively and the efficiency of operation. The application of this technique has greatly improved the sampling success rate in neogene unconsolidated sandstone reservoir in Bohai oilfield, bring obvious economic benefits and great significance of promotion.

Keywords

Bohai Oilfield; Unconsolidated Sandstone; Safety Production Differential Pressure; Differential Pressurecontrol; Sampling Success Rate.

1. Preface

Pressure sampling is a very important logging method to extract the formation fluids visually, analyze the formation pressure, permeability, etc. However, because of the affect of formation, well conditions, drilling fluid properties, sampling instruments and other factors, the sampling yield rate cannot be guaranteed. Current problems: (1) there is no standard for the differential pressure control of pump when sampling, and it is often tried gradually from small to large, with low efficiency; (2) Due to the difference volume of bidirectional positive displacement pump in the traditional EFDT instrument pump module, the changes of differential pressure are greatly when the fluid pump changes direction, and the leakage probability is high; (3) The speed range of the fluid pump is small (3.75-11.625cc/s), sand influx easily, which limits the pump speed reduction in heavy oil and low porosity and permeability reservoirs. The sampling technique with precise controlled pressure and speed regulation through calculation, determine a reasonable differential pressure, and improve the pump pressure control module, to achieve accurate control of differential pressure, so that the instrument can sampling in a stable and continuous state, improve the success rate of sampling obviously, this technology take the leading position in the industry.

2. Major technology

2.1. The technology of flow pressure control based on array acoustic and density logging data

Applying array acoustic and density logging data and Mohr-coulomb fracture criterion, the safety production differential pressure and sand production differential pressure in sandstone reservoir are calculated. By correcting the key parameters of different zones in different blocks, more accurate safety differential pressure calculation results can be obtained. The practice proves that when the differential pressure of sampling is less than the safety production differential pressure, the leakage probability is less than 15%. When the differential pressure of sampling is greater than the safety production differential pressure and less than the sand production differential pressure, the leakage probability is 15%-50%. The differential pressure of sampling is greater than the sand production differential pressure, the leakage probability is greater than 50% (Table 1); Create the standard of differential pressure control process for neogene sampling operation to improve sampling efficiency under the precondition of stable flow pressure control without leakage.

Table 1. Relationship the differential pressure of sampling and leakage probability

The differential pressure of sampling	leakage probability
The differential pressure of sampling < safety production differential pressure	<15%
safety production differential pressure < The differential pressure of sampling < sand production differential pressure	15%-50%
The differential pressure of sampling > sand production differential pressure	>50%

2.2. The technology of speed control and pressure control based on double pump combination

The application of isobaric differential pressure with long-stroke precision pump module (isobaric differential pressure pump) coordinate with broadband speed regulation power joint (low speed pump) into the well at the same time, precise control of differential pressure pump speed, effectively improve the success rate and efficiency of operation.

2.2.1. Isobaric differential pressure control technology

The Isobaric differential pressure pump module can realize the single stroke displacement from 500ml to 820ml, and the pumping efficiency is higher; The maximum working differential pressure is increased from 5,300psi to 7,000psi, achieving the same bidirectional differential pressure and displacement, and more stable operation. The problem of unstable pump pumping rate due to the large change of reversing differential pressure is completely solved, which reduces the probability of leakage and sealing caused by sudden increase of pressure drop during reversing of fluid pump, and improves the one time success rate during the operation.

2.2.2. Broadband speed regulation technology

According to Darcy's deformation formula 1, the differential pressure of sampling is proportional to the pump speed, and the low differential pressure corresponds to the low pump speed. The broadband speed regulation power joint is upgraded from single pump to double pump, and can be switched freely downhole; Wider speed range, from the original 1000-3000rpm adjustable upgrade to 100-3500rpm; Pumping rate is wider, from the original 3.75-11.625cc/s upgrade to 0.1-15cc/s, completely solve the problems that the fluid pump speed range is small, and the pump speed is limited.

3. Field practice practice

3.1. Effect of single well

A sampling point was designed at 1311.50m for the fifth well in Kenli. The sampling technique with precise controlled pressure and speed regulation was applied to calculate the safety production differential pressure and sand production differential pressure are 1.45psi and 137.75psi respectively at this point. According to the standard differential pressure control process, the optimal differential pressure was about 90psi. The application of isobaric differential pressure pump module with broadband speed regulation joint make the pump speed is about 2cc/s, this effectively prevent oil and gas breakthrough and the leakage occurred caused by the differential pressure is too large during the pumping process. In the actual sampling process, 1600ml of pure oil sample was obtained by pumping for 100min.(Fig.1).

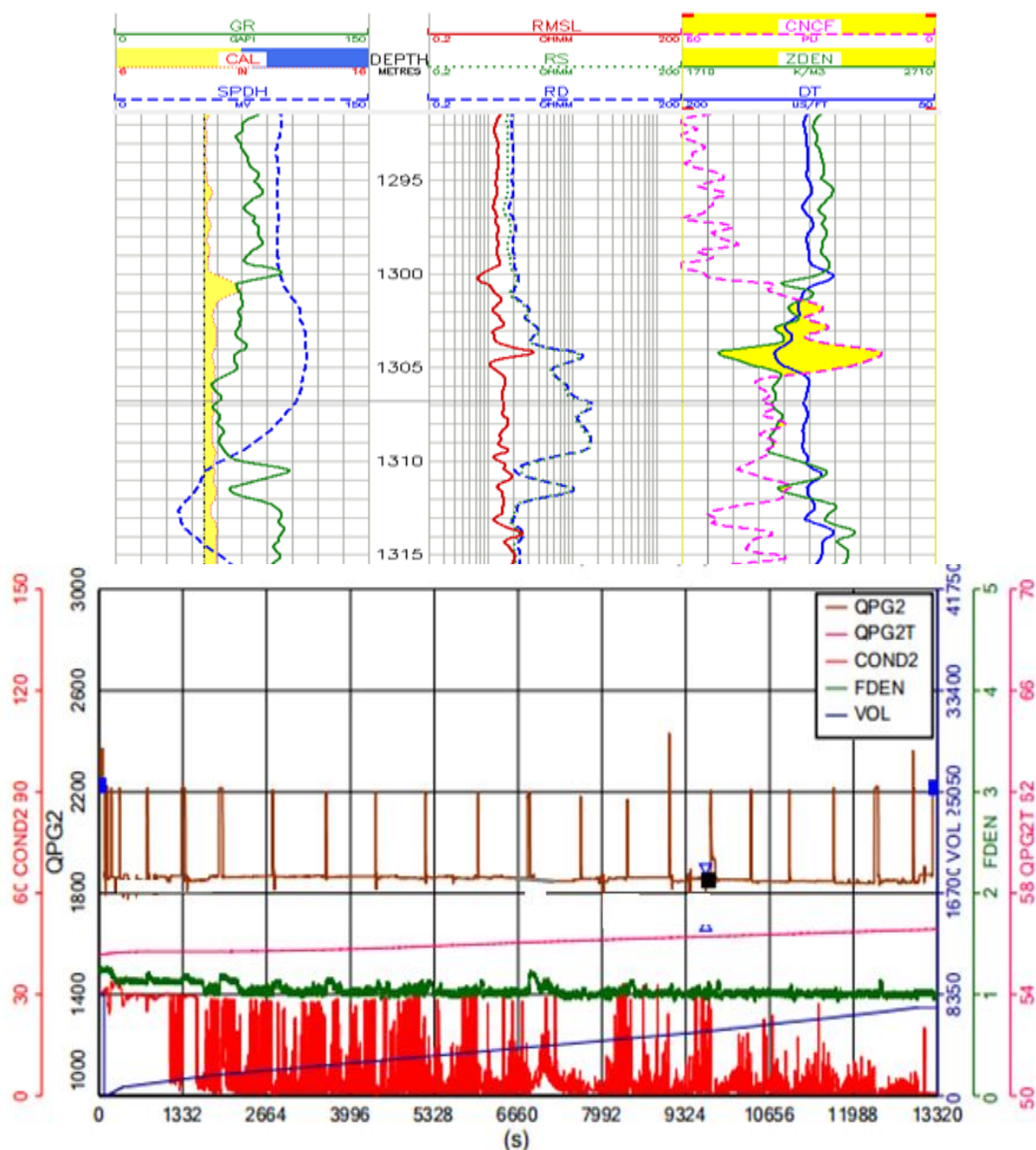


Figure 1. The parameter variation at 1311.50m of the fifth well in KenLi

3.2. Effect of an area

In 2020, 5 Wells were successfully operated in a structure and enclosing area in Kenli, and 10 samples were obtained. The one time sampling success rate was 100%, which increased by 26% compared with 2019, and helped the exploration and evaluation of a 100-million-ton oil field in Kenli.

In 2020, 72 samples were obtained, and the sampling success rate reached 100%. The average number of repeated attempts after leakage sealing was reduced by 0.5 hours at a single point. In 2020, the average sampling time at a single point was reduced by 0.5 hours, and more than 5 million yuan benefit of the annual economic was achieved.

4. Conclusion

(1) Using array acoustic, density logging data and Mohr -Coulomb fracture criterion to calculate the safety production differential pressure and sand production differential pressure in sandstone reservoir can guide the pressure control during the sampling process, especially in mature areas.

(2) The Isobaric differential pressure pump module has higher pumping efficiency, which can realize the same bidirectional differential pressure and displacement, and run more steady. It can solve the problems that the large change of the reversing differential pressure and the instability of the pumping speed rate.

(3) The broadband speed regulation power joint is upgraded from single pump to double pump, which can be switched freely downhole; The wider speed range can solve the small speed range of the fluid pump and the limited pump speed.

(4) The success of this technology system is based on the accurate calculation of formation differential pressure. Therefore, the calculation of formation differential pressure in safety production can be further studied to better guide the field operation.

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