Bit Optimization for Che 47 in Carboniferous Stratum

Xiaorui Sun¹, Baichuan Wu²*, Cheng Ye¹, Fuwei Han³ and Nan Zhang¹

¹Engineering Technology Institute of PetroChina Xin Jiang Oil Field Company, Karamay, Xinjiang, 834000, China
²Petroleum Engineering College, Yangtze University, Wuhan, Hubei, 430100, China
³CNPC Bohai Drilling Engineering Co. LTD. Third Drilling Company, Tianjin, 300280, China

*Corresponding author’s e-mail: shengzh199242@163.com

Abstract. The Carboniferous in the Well 47 area is dense and hard, with strong abrasiveness and low mechanical drilling speed. According to the correlation between the logging and the completed drilling data in the Carboniferous system, the lithology distribution of the strata in the Che 47 well area was determined, and the bit selection was carried out in combination with the bit wear and broken teeth. At the same time, the optimized drill bit was applied on site. The field data show that the lithology of the Carboniferous strata in the Well 47 was complex. The upper strata are soft and hard, and the lithology of the lower stratum was dense and hard. The optimized drill bit could increase the drilling speed of the whole well by 4.63 times and the average drill bit increase by 3.84. It achieved the purpose of drilling speed increase, and achieved good application results.

1. Introduction
The Che 47 well area is located in the Chepaizi area on the north-western margin of the Junggar basin. The fault is developed in the area, and the near-south-north-trending reverse fault system is the main controlling fault. According to the local geological data, the upper lithology of the Tuyulu group is dominated by mudstone and sandstone, and the bottom is glutenite. The upper lithology of the Carboniferous is dominated by sandstone, with mudstone and andesite in the middle. In the lower part, it has glutenite and andesite. Due to the complex lithology of the Carboniferous system and the poor matching of the drill bit model, the average mechanical drilling speed of the completed drilling is 1.61m/h. Most of the drilling operations are combined with the screw and the PDC bit, without understanding the different parts of the block. There is no in-depth understanding of the differences between different strata in this area, and the matching of speed-up technology with strata is poor.

2. Engineering and technical difficulties
2.1. Stratigraphic lithology
According to the logging data of the Che 47 well area, the uniaxial compressive strength, gamma value and rock drill ability profile were established in the Carboniferous block.
It can be seen from Fig. 1 that the uniaxial compressive strength of the Che 47 well area from the Badaowan (J1b) to the Carboniferous (C) is obvious. Although the uniaxial compressive strength is not high in the red frame, the amplitude of the natural potential is in the trough. The gamma curve value increases, indicating that the lithological shale content is high at this position. The rock drill ability extreme value 7 (marked by the red line) corresponds to the uniaxial compressive strength at the peak, which belongs to the hard rock formation [1]. Therefore, the Carboniferous regional stratigraphic lithology is more complex, which is the key speed-up stratum.

In the drilling Che 479 well, pressure constraints occurred at the depth of 2408 m (density 1.25g/cm3, viscosity 65s) and 2530 m during reaming, the pumping pressure raised rapidly from 9MPa to 13MPa (see Figure 1). The lifting process was severely stuck and always accompanied by the pulling of the piston. The peak of the gamma logging curve is at 2470~2520 meters, which corresponds to the lower mechanical drilling speed and the sudden increase of pump pressure. The lithological mud content is high, and it is easy to lift the piston and mud pack on the drill bit.

2.2. Low mechanical drilling rate
According to the local drilling data, the drilling rate of the Carboniferous stratum is low, the fluctuation range is large, and the average mechanical drilling rate is only 1.82m/h. During the drilling operation, the drilling pressure fluctuates obviously when the drill bit is at the depth of 2500 meters. After checking the drilling log, there have been many bit bounce.
3. Bit Preference

3.1. Bit failure analysis
The main failure mode of the PDC bit is the nose and shoulder collapse of the bit [2]. When drilling into the Che 47 well area, the bit has many complicated conditions of severe wear, broken teeth and mud packs. The bit failure is concentrated in the Carboniferous stratum.

From the crack propagation pattern on the cutting teeth in Fig. 3, it can be seen that the shoulder teeth have similar "beach" type cracks, which indicates that they are impact damage caused by eddy [3]. Due to the Carboniferous lithology is soft and hard interlaced, the variation of drilling pressure is large. The amplitude is large (see Figure 2). Under high speed and low drilling pressure, the bit whirl is easily generated, resulting in shoulder collapse.

3.2. Drill selection

Table 1. Selection parameters of the Carboniferous layer bit in the 47 area of the vehicle

| Bit name | Application layer | Blade design | Water structure | Tooth arrangement design | Other design features |
|----------|-------------------|--------------|-----------------|--------------------------|----------------------|
| GSD1675TZ (Before selection) | Upper Carboniferous | 7 blades | 5 nozzle | 16mm Composite sheet | Steel body drill |
| GS1665Z (Before selection) | Lower Carboniferous | 6 blades | 5 nozzle | 16mm Composite sheet | Steel body drill |
| S1655JA (After selection) | Upper Carboniferous | 5 blades | Large flow channel, 7 nozzle | Double row, 13mm and 16mm composite | Steel body drill, Anti-mud coating design |
| HIT537GK (After selection) | Lower Carboniferous | 5 blades | 6 nozzle | 19mm composite piece aggressive cloth ruler | Steel body drill, Anti-mud coating design |
| S1955G (After selection) | Lower Carboniferous | 5 blades | 6 nozzle | 19mm composite piece aggressive cloth ruler | Steel body drill, Anti-mud coating design |

4. Application
The optimized drill bit was subjected to large-scale field test in wells such as the Che 475 well and the Che 484 well. The rate of drilling of the Carboniferous was significantly improved and the drilling cycle significantly shortens. An average of four bits are needed to complete the drilling. There was no broken tooth during the test.
By comparing the data before and after the selection, before the bit optimization, the average penetration rate of the carboniferous PDC bit was 1.61 m/h, and the average penetration depth of a single bit was 83.6m. After the bit optimization, drilling efficiency has been greatly improved, with the average penetration rate of 7.83 m/h. The average penetration depth of a single bit of 403.6m, which is 4.63 times higher than before the optimization. The drilling efficiency has been greatly improved, and the drilling cost in Che 47 well area has been greatly reduced.

5. Conclusion
(1) For the upper part of the Carboniferous, mud pack and broken tooth of the bit are prone to occur. The lower part of the drill bit is prone to serious wear and tear failure. By consulting relevant data, a representative drill bit is preferred for different intervals. Thus, the rock carrying efficiency and impact resistance of bit bottom hole are improved, and efficient drilling in hard formation and multi-interlayer formation is realized.

(2) Field experiments show that the average mechanical drilling rate of drilling into the Carboniferous strata is 7.83 m/h, which is 4.63 times higher than the optimized drilling speed. The average drill depth of a single drill bit is 403.6m, which achieves the purpose of speeding up the drilling and good application results.

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