Application Test of Steel Body PDC Bit in Mahu Well Area

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Abstract. The western ring belt of Mahu depression is located in the Mahu well area of the western slope of the central depression of Junggar basin. According to the actual drilling data, the reservoir pressure in this well area changes greatly and is affected by fracture, lithology and seismic data quality. It is difficult to accurately predict the pressure before 3d drilling, and the mechanical drilling speed and single drill footage are very low. To this end, the 9-1/2”SF56VH3 and 6-1/2” SF54VH3 PDC bit was developed in Mahu well area, and the downhole condition of the bit was simulated by finite element software. The results show that: In the application of 60 Wells, the average mechanical drilling speed of the whole well is 7.24m/h. Special Ma6229 well three - open average speed up to 10.72 m/h, which fills the gap of Xinjiang in the field of personalized design of PDC bit. Meet the needs of Mahu oilfield.

1. Introduction
The current PDC bit is mainly produced domestically or imported from abroad. However, the domestic drill manufacturers have a relatively small scale and weak. The rationality of the PDC bit design and its adaptability to the conglomerate strata in Xinjiang has always been difficult to overcome [1]. Therefore, it is of great significance to carry out in-depth research on steel body PDC bit technology and processing manufacturing technology. Among them, computer-aided design (CAD) technology and finite element simulation provide a solid theoretical basis for the development of new drill bits [2].

2. Steel body PDC drill technical characteristics

2.1. Difficulty in selecting the drill bit
The Jurassic Sangonghe formation in Mahu well area is mainly composed of mudstone and sandstone. But the lower part is mainly grey fine sandstone, siltstone and middle sandstone. The lower part of Badaowan formation is mainly composed of grey sand conglomerate, gravel medium sandstone and gravel coarse sandstone. The compressive strength of rock increases gradually from top to bottom. The content of coarse sandstone and gravel increased with the well depth, the abrasion and impact damage of PDC bit are also increased, which makes it very difficult to select the drill type.

On the basis of laboratory rock mechanics experiment, the rock mechanics characteristic and drillability profile of typical well formation are established, Provide theoretical guidance for bit optimization [3,4]. The drilling speed is restricted by the multiple sets of gravel and sand conglomerate in the longitudinal direction of the Ma18 well area. The homogeneity of Triassic stratum is poor, drillability level 5-7, The uniaxial compressive strength of gravel layer >60MPa.

| model | Blade number | Type of cutting teeth | Diameter of cutting teeth | Jet number | Apply formation          |
|-------|--------------|-----------------------|---------------------------|------------|--------------------------|
| 12 1/4"FX65DsVX3 | 6 | X3 tooth | 113 | 6 | Medium-hard formation |
| 9 1/2"SF56VH3 | 5 | H3 tooth | 55 | 7 | Soft, medium hard formation |
| 6 1/2"SF54VH3 | 5 | H3 tooth | 33 | 5 | Soft, medium hard formation |

2.2. Technical parameters and characteristics of steel body PDC bit
Mahu well area USES special alloy steel to make drill bit (steel body bit), which solves the technical bottleneck that the height design of drill bit blade is limited; In the design of the drill bit, the latest technologies, such as large blade, wide chip groove, asymmetric blade, spiral blade, and spiral diameter protection, are adopted, the stability of the drill in underground operation is ensured [5]. In order to improve the drill life, PDC cutting elements with high wear resistance and impact resistance were developed. The range of strata used by PDC bit has been widened.
3. Finite element simulation of rigid PDC bit

3.1. Establishment of PDC bit model
In view of the stratigraphic characteristics of the western ring belt in Mahu depression, carry out personalized design to improve PDC bit aggression, IBitS software was used to design the drill bit, as shown in figure 4.

3.2. Dynamic simulation of PDC bit flow field
First, the model is used for unit selection and grid division. The model is used for finite element analysis and calculation. Reasonable selection of cell types and shapes and arrangement and layout of grid are very important. When the model is partitioned into cell grids, Tetrahedron 10-node element (tetrahedron 10-node element has high stiffness and high computational accuracy) was selected.

In terms of computation time and precision, Set the unit size to 10, Cell division using free grid. At the same time, the software automatically arranged dense grids in relatively small structural feature areas under the bit. For example, in the area where the stress changes gently, a sparse grid is arranged. In this way, both accuracy and efficiency can be satisfied. Thus, the finite element model of the bottom body of the drill is generated. The finite element model consists of 52070 units and 83017 nodes.

3.3. Static structure simulation of PDC bit
Static analysis is mainly used to analyse the structural strength of an object under the maximum instantaneous load. For the bottom of the drill, the worst working condition is that when the drill is trapped underground, the maximum torque of the rotary disc will be loaded on the bottom of the drill. The lower body of the drill is suffocated and stopped when it works underground, mainly due to falling down and overeating. Therefore, the load analysis is carried out for the bottom body of the drill when the drill is stopped.

A boundary constraint is applied to the joint of the lower body of the bit. Load torque load and drilling pressure on the cutting teeth on the lower body of the bit. At 8 1/2 SF56H3, the normal operating torsional distance of the drill is about 3000N.m, and the safety working torque of the rotary disc set by
the drill is about 15000N.m. For the consideration of impact inertia and safety coefficient, the load
torque of finite element analysis on the bottom body of the drill is 20000N.m. 8 1/2 SF56H3 drill bit
working drill pressure is the maximum of 12T. The above torsion distance and load distribution are
loaded onto the cutting teeth under the main force, and then the calculation is carried out. The result
shows the displacement cloud diagram as shown in figure 6.

3.4. Check the strength of the drill body
The material under the bit is ASTM 4130. It can be seen that the tensile strength of the material is 832
N/mm², so its allowable stress is

\[ \sigma_{zu} = 0.2 \sigma / \gamma M \]  

(1)

According to the actual calculated stress results:

\[ \sigma_{max} = \sigma \times v \times k \]  

(2)

The bottom body of the drill is calculated at the position of the fifth blade, its maximum stress value
is stable and strong enough, because its allowable stress Max is less than that of the material.

4. Application effect analysis
According to the statistics of 60 Wells using Xinjiang DBS drill, the statistics of the four types of well
bit indexes of the rigid bit in Mahu. The mechanical drilling speed reaches 8.76 m/h at the location of
small three-well drilling, which is the highest in the whole well type. By the statistics, the actual average
mechanical drilling speed of the whole well is 7.24m/h, and the total footage of PDC bit is 243,000
meters. This is 31% higher than before 2014, with an average drilling cycle of 54.2 days.

In 2015, due to the remarkable acceleration results in the Mahu well area, a number of well drilling
cycles were completed within 50 days. The Wells MaHW1325, Ma6025 and MaHW6004 have set
records for only 7 to 8 days of drilling. The block records of 6 Wells including MaD5324 with a drilling
time of only 4-10 days were recorded. In particular, the opening time of the Ma6229 well was only 4.4
days, with an average speed of 10.72 meters per hour, and the drilling was completed 13 days in advance.

5. Conclusion
(1) Research and development of 9-1/2 "SF56VH3 and 6-1/2" SF54VH3 PDC bit solves the drill bit
blade height design limited technical bottlenecks, developed with high anti-wear and high impact of
PDC cutting element, broaden the scope of PDC bit using formation.
（2）Through the finite element software of rigid body bit flow field simulation and the statics, the results consistent with the downhole conditions, for research and development and application of bit provides ample theoretical basis.

（3）In the construction process, the average mechanical drilling speed of the new rigid body bit in the whole well is 7.24m/h. In particular, the average speed of the three-open machine in well Ma6229 reaches 10.72 m/h, which meets the needs of the field of Mahu oilfield.

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