Research and Development of Drilling Operation Data Benchmarking Management System

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Abstract. Benchmarking management, as a measure for the continuous improvement of scientific management of enterprises, provides advanced ideas for enterprises to analyze the problem of insufficient production capacity, and through data modeling can provide solutions for the improvement of deficiencies, which is conducive to the improvement of the overall management level and competitiveness of enterprises. Changqing Drilling Corporation has a large difference in the speed of drilling among the drilling crew, and has not formed an overall drilling speed-up plan. This paper uses an integrated data platform to establish a drilling operation benchmarking management system model, through the comparative analysis in different regions, different operation conditions of ROP and drilling cycle. Using machine learning to establish a benchmark optimization model for ROP and drilling cycle, in order to lay a foundation for drilling operations to improve operating efficiency and reduce operating costs.

1. Introduction
Benchmarking management is derived from English Benchmarking, also known as “Standard management” or “Pole management”. It is an advanced enterprise technology management process and management method[1], which reflects the level of enterprise management and is also an effective management method. The primary task of benchmarking management is to establish the optimal level of the enterprise "indicators", and to decompose and refine the indicators to each business activity in production activities[2-3]. It is a virtuous cycle mode of enterprise management to constantly compare actual engineering activities with the optimal "indicators" and take certain measures for continuous improvement so as to make operational activities close to or even exceed the optimal one[4-5].

Chuanqing Drilling Company has different performances between different blocks and different drilling crews in the same block. Each drilling crew has different speeds in the drilling cycle, and there are big differences. Because the drilling data comes from various operations in the drilling process, there are many types and large amounts of data, and there is insufficient data management. In addition, the drilling speed is affected by various factors such as the engineering parameters of the drilling process, underground geological parameters making the excellent fast drilling more dependent expert experience, how to make full use of historical drilling data to establish a benchmarking model for drilling operations, and form a set of drilling benchmarking decision-making optimization system for guiding the
construction of the drilling crew has important guiding significance for guiding the construction of the well team and promoting the optimal and fast drilling of the drilling crew.

2. ESTABLISHMENT OF DRILLING DATA BENCHMARKING MODEL

At present, Changqing Drilling Corporation has formed a complete drilling data acquisition and data management system. The data management adopts an integrated drilling well history data management method. The data business scope covers drilling operation construction data, drilling operation engineering parameters, drilling geological formation information and other data categories. The drilling data benchmarking model is formed by comparing and analyzing the drilling cycle, ROP, and bit selection of different blocks, different formations, and different drilling teams. As each data is filled in unevenly, data quality evaluation must be passed before data benchmarking analysis to realize data governance, and then compare the optimal value and average value of each benchmarking parameter through statistical analysis to provide a reference for the establishment of the benchmarking model. Finally, use regression methods and machine learning to establish a benchmarking model to analyze the impact of different operating parameters on the indicators. The influence law and the weight coefficient of each parameter in different indicators are finally achieved through the data benchmarking analysis and comparison to realize the optimization of engineering parameters, the prediction of ROP and the optimization of construction schemes. The benchmarking model establishment process is shown in Figure 1.

Fig. 1 The establishment process of drilling operation data benchmarking system

2.1. Benchmarking model system for drilling cycle, ROP and bit selection based on drilling operation data

The purpose of drilling operations is to safely and quickly drill the wellbore from the wellhead to the designated target point through engineering means, so that oil and gas can be produced to the surface through the wellbore channel. Drilling operation is a complex underground construction project. Due to the uncertainty of geological information and construction technology constraints, drilling is a high-risk and high-investment engineering business activity. How to complete this operation safely and reliably, to achieve the goal of reducing operating costs, improving operating quality and efficiency, is the continuous pursuit of the petroleum engineering drilling industry.

The construction of the drilling data benchmarking system is the basis for the implementation of benchmarking. The construction of a reasonable benchmarking system requires not only a good grasp of science, rationality, and practicability, but also operability. The index parameters must not only reflect the real operation. It can also cover the key points of the operation link. For this reason, around the whole process of drilling operation, this article chooses to establish benchmarking models based on
drilling cycle, ROP, and drilling operation timeliness. Through subdivided each benchmarking model into the secondary index, it quantifies the benchmarking management to specific data. The benchmarking management system and index model of drilling operations are shown in Table 1.

Table 1  Index model of drilling operation data benchmarking system

| Level 1 benchmarking model | The secondary indicators | Index meaning |
|---------------------------|--------------------------|--------------|
| Drilling cycle            | Moving time              | Analyze the time in each operation link and find out the time composition of each stage of different blocks and well crews |
|                           | Drilling time            |             |
|                           | Cementing time           |             |
|                           | Log time                 |             |
|                           | Stop-and-wait time       |             |
|                           | Stratigraphic and rock parameters | By analyzing various factors that affect the ROP, establish a ROP prediction model to achieve benchmarking and optimization |
|                           | Bit nozzle parameters    |             |
|                           | Construction operation parameters |             |
|                           | Drilling fluid hydraulics parameters |             |
| ROP                       | Drilling time            | Analyze and compare different operating timeliness under different blocks, strata and operating conditions, then establish timeliness benchmarking models |
|                           | Production time          |             |
|                           | Non-production time      |             |
| Drilling time             | Trouble handling time    |             |
|                           | Failure handling time    |             |

2.1.1. Drilling cycle benchmarking model

The drilling cycle is mainly from the start of a single well to the completion of drilling. This cycle is used to measure operating efficiency. According to different types of operations, the drilling cycle can be subdivided into installation time, drilling time, cementing time and measurement. Multiple secondary indicators, such as wellhead time and waiting time. It is a comprehensive consideration index of completion time. It evaluates operational efficiency from the entire operation process. The speed of the drilling cycle directly affects the operating efficiency and operating cost of the drilling rig. Therefore, it is necessary to conduct a further detailed analysis of the influencing parameters of each secondary index to find out the insufficiency of different operation stages to make up, and then improve the overall operation level and operation efficiency.

2.1.2. ROP benchmarking model

The ROP is an important index for evaluating drilling efficiency, and the ROP is the most core direct evaluation index of drilling efficiency in drilling operations. In the actual engineering operation, there are many factors affecting the ROP, which can be roughly divided into two categories based on different properties. The first category is stratum and rock parameters, such as stratum layer type, rock drillability, rock mineral content and rock porosity permeability, etc. These factors are mainly related to the drilling area and the drilling strata reconstructed by operating means; the second category is operating parameters, which mainly include drill bit type and bit nozzle parameters, drilling fluid performance and rheological parameters, and engineering parameters in drilling operations such as weight on bit, rotation speed, displacement and turntable torque. These parameters are all engineering controllable parameters, and the best ROP can be achieved by adjusting these parameters [5-6].

The establishment of the ROP benchmarking model requires big data statistical analysis based on historical operating data. At the same time, an accurate correlation model between ROP and influencing factors can be established to characterize the quantitative relationship between the ROP and the influencing factors. Provide guidance for optimizing construction parameters in the next step. The establishment of ROP index optimization model mainly includes several key links such as data smoothing, machine learning optimization model establishment, and optimization model prediction analysis.
2.1.3. **Drilling time efficiency benchmarking model**

Drilling aging benchmarking is a detailed comparison and analysis of various agings in the drilling cycle aging, mainly including pure drilling time, production time, non-production time, complex time, accident time, etc., so as to visually show the different drilling team and the operating efficiency between different blocks, which are further analyzed by combining pure drilling time benchmarking with ROP indicators to provide a basis for the optimization of drilling operating parameters. By analyzing the ratio of production time and non-production time, the efficiency of single well operation can be quantitatively analyzed. In view of the insufficient efficiency of single well operation, the main influencing factors of non-production time can be further analyzed to provide guidance for optimizing operation management and improving operation efficiency. In the benchmarking analysis of complex and accident processing time, statistical analysis of the causes of complex accidents can be used to establish complex accident symptom models and complex accident probability models to provide support for reducing the occurrence of complex accidents and improving the efficiency of complex accident handling.
3. Development of Drilling Data Benchmarking Decision Optimization Analysis System

Based on the establishment of the drilling data benchmarking system model, a set of drilling data benchmarking decision-making optimization system is developed to solve the key problem of large differences in drilling efficiency and drilling speed among well teams, which can be realized that making full use of engineering data to analyze the impact of operating parameters on drilling efficiency under different formation conditions. It also has important practical engineering applications for guiding the speed of operations and forming a regional overall speed-up plan.

The main functions of the system mainly include (1) Establishing the analysis of all well indicators under different conditions (blocks, well categories, well types), and statistically forming comparative analysis charts of different indicators; (2) Based on the continuous growth of historical data, dynamic statistics of the optimal and average index values under different strata and working conditions are made to form a regional optimal index statistical analysis chart; (3) Based on the real-time data of historical operations, establish the optimization relationship model between engineering parameters such as different blocks, well types, well categories, WOB, rotation speed, pump pressure, displacement and the ROP indicators; (4) According to the previously established optimization model and the real-time operating parameters of forward drilling, the difference between the well ROP and the optimal and average indexes of the block is analyzed, and the recommended values of the optimal operating parameters are given.

4. CONCLUSION

(1) This paper establishes a benchmarking system for drilling operation data based on integrated historical data, covering benchmarking models such as drilling cycle, ROP and drilling timeliness. This model provides engineering guidance for improving operation efficiency.
Aiming at the ROP model in the established index system, using big data analysis can establish a ROP machine learning model, which can provide a theoretical basis for further optimization of the ROP.

The optimization analysis system developed in this paper, based on statistical analysis of data, combined with benchmark model analysis, provides new ideas and solutions for drilling optimization decisions.

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