Evaluation method of gas well dynamic reserves in low permeability gas reservoir based on big data analysis

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Abstract. The evaluation of gas well dynamic reserves is the basis of gas reservoir development potential analysis, technical policy-making, economic benefit evaluation. The low permeability gas reservoir has a small percolation capacity, long pressure recovery time and limited formation pressure test data, which bring great difficulties to the evaluation of gas well dynamic reserves. Based on the development practice data of more than 1000 gas wells and over 20 years of M gas field in ordos basin, the relationship model between dynamic reserves of gas wells, casing pressure and cumulative gas production volume was established through big data analysis, to quickly evaluate the dynamic reserves of gas wells in low-permeability gas reservoirs using conventional production data. The production practice of the M low permeability gas field shows that this method can effectively improve the number and accuracy of dynamic reserves evaluation wells

Keywords: Big data, Low permeability gas reservoirs, Dynamic reserves, Casing pressure, Cumulative gas production.

1. Introduction
Dynamic reserves are the geological reserves calculated by dynamic methods such as pressure drop method and decline analysis method. At present, dynamic reserve evaluation methods mainly include pressure drop method, production instability analysis method, etc. These methods are mainly based on material balance and seepage theory, and objective evaluation of dynamic reserves can be achieved through the formation pressure, cumulative gas production, bottom-hole flow pressure, and other visually testable explicit data. For high permeability reservoirs, this method has good adaptability due to the strong permeability of the reservoir, a small number of gas wells, a short time for shut-in formation pressure to recover stability, and abundant testing data of formation pressure [1-6]. However, due to a large number of wells in low permeability gas reservoirs, the long recovery time of formation pressure, limited bottom-hole pressure test data, it is difficult to comprehensively and accurately evaluate the dynamic reserves of gas wells. Based on the development practice data of more than 1000 gas wells and more than 20 years of M gas field in the oridos basin, and using big data analysis, the prediction model of gas well dynamic reserves in low permeability gas reservoir is established, which provides a basis for the evaluation of gas well dynamic reserves in low permeability gas reservoir.
2. Basic methods of big data analysis
Big data analysis refers to the analysis of large-scale data [7-12]. Big data analysis has five characteristics: volume, velocity, variety, value, and veracity. According to CRISP-DM data mining standard flow, a dynamic reserves evaluation and analysis flow based on big data were designed.

![Flow chart of gas well dynamic reserves evaluation based on big data analysis](image)

3. Evaluation method of gas well dynamic reserves based on big data analysis
The production characteristics of the gas well are the direct expression of gas well dynamic reserves. Based on big data analysis, the relationship between gas well production characteristic parameters and dynamic reserves was explored, and the dynamic reserves prediction model was established to provide a basis for gas well dynamic reserves evaluation.

3.1. Data collection
Big data collection refers to the use of multiple databases to receive data from the client (in the form of Web, App or sensor, etc.), and users can conduct simple queries and processing through these databases. Data collection in this study is mainly realized through the oilfield digital platform, which mainly includes daily production data of single well (date, time rate of well opening, oil pressure, casing pressure, daily gas production, daily water production, etc.) and dynamic reserve evaluation results of typical gas wells.

3.2. Data Preprocessing
To effectively analyze these massive data, it is necessary to import the single-well daily production data and dynamic reserve evaluation data from the digital platform into a centralized database, and do some simple data cleaning and preprocessing based on the import.

The data preprocessing of this study mainly includes two aspects: one is to analyze and extract indicators representing dynamic reserves of gas wells from daily production data of single well; the other is to evaluate the reliability of dynamic reserves of evaluated gas wells and delete the evaluation data of dynamic reserves of gas wells with poor reliability. Therefore, on the one hand, the research is
based on material balance method, in the original formation pressure and the present formation pressure is constant, gas well dynamic reserves as tired of gas production rate is directly proportional to the function because obtaining difficult formation pressure, casing pressure and can reflect the characteristics of the formation pressure change, therefore, will be set under the pressure and the corresponding set of exhausted gas production rate as the influence factors of dynamic reserves prediction; At the same time, the macro command is written through VBA to automatically extract the casing pressure of the gas well and the cumulative gas production under the corresponding casing pressure into the formulation worksheet. On the other hand, through the reliability evaluation of formation pressure and RTA model, the evaluation results with poor reliability were deleted.

3.3. Data Preprocessing
Based on the material balance method, the dynamic reserves of the gas well are related to casing pressure and cumulative gas production. The correlation between dynamic reserves and cumulative gas production under different casing pressures was studied by drawing the intersection diagram. The results show that, when casing pressure is constant, there is a good proportional relationship between dynamic reserves and cumulative gas production, namely:

\[ G = K_i \cdot G_p \]  

(1)

**Figure 2.** Intersection diagram of dynamic reserves and cumulative gas production in gas Wells under different casing pressures

Meanwhile, the proportional coefficient \( K \) of gas well dynamic reserves and cumulative gas production is exponentially related to the corresponding casing pressure, namely:

\[ K_i = 0.8749e^{0.1213p_i} \]  

(2)
Substitute equation (2) into equation (1), then:

$$G = 0.8749e^{0.1213P} \cdot G_p$$

(3)

Using formula (3), the evaluation of dynamic reserves of gas wells can be realized according to conventional production data such as casing pressure and cumulative gas production.

### 3.4. Model Training and Optimization

According to the new method of gas well dynamic reserves evaluation, the dynamic reserves of 10 gas wells in well S of M gas field were evaluated, and the results were compared with the dynamic reserves evaluation results of the pressure drop method. For example, well W10 was put into operation on October 10, 2003. By March 24, 2010, the total gas production was $0.27 \times 10^8 m^3$ and the wellhead casing pressure was 6.4MPa. According to the new method, the calculated dynamic reserves were $0.53 \times 10^8 m^3$, which was consistent with the evaluation result of the pressure drop method of $0.56 \times 10^8 m^3$. 

**Figure 3.** Dynamic reserves proportional coefficient and casing pressure diagram

**Figure 4.** Well W10 production curve
The analysis shows that the new method is adopted to evaluate the dynamic reserves and pressure drop method in 10 test wells, and the average absolute error is 5.5%.

Table 1. A comparison table of dynamic reserves evaluation results in Shaanxi 43 well area

| Well name | New method to evaluate dynamic reserves $(10^8m^3)$ | Dynamic reserves evaluation by pressure drop method $(10^8m^3)$ | Error (%) |
|-----------|-----------------------------------------------|------------------------------------------------|----------|
| W1        | 3.62                                          | 3.53                                           | -2.5     |
| W2        | 2.87                                          | 3.01                                           | 4.7      |
| W3        | 2.65                                          | 2.80                                           | 5.4      |
| W4        | 1.66                                          | 1.57                                           | -5.7     |
| W5        | 2.42                                          | 2.32                                           | -4.3     |
| W6        | 2.28                                          | 2.13                                           | -7.0     |
| W7        | 2.14                                          | 2.05                                           | -4.4     |
| W8        | 1.04                                          | 1.12                                           | 7.1      |
| W9        | 0.72                                          | 0.79                                           | 8.9      |
| W10       | 0.53                                          | 0.56                                           | 5.4      |

4. Conclusions and Suggestions
Based on more than 1000 M of ordos basin gas field breath well, more than 20 years of development practice data, the dynamic reserves of gas well is established through the analysis of the large data evaluation model, solve the problem of no formation pressure test of gas well dynamic reserves evaluation, greatly expanded the number of low permeability gas reservoir dynamic reserves evaluation wells, scope, has great practical value and economic value.

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