Application of acidification parameter optimization method

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Abstract. The acidification technology is an important measure to increase the production and increase the injection of oil and water wells. However, due to the complicated working conditions of the acidification measures and the difficulty in determining the construction parameters, it is necessary to establish the acidification model of the injection wells and optimize the parameters. The paper uses the grey correlation analysis method to find the correlation between each construction parameter and the daily injection volume of the injection well, establishes the BP neural network program, trains it according to the existing data and predicts the artificial controllable parameters in turn to find the best construction parameter combination. Taking a single well as an example to predict the parameters and guide the on-site construction. The results show that combining the mathematical method with the acidification construction technology of the injection well and establishing the model prediction parameters can significantly improve the injection efficiency of the injection well.

1. Introduction

In the later stage of water injection development, the oilfield is seriously blocked. The dissolution of rock cement or formation pores and plugs in the cracks can reduce the permeability of formation pores and fractures by increasing the permeability of the formation pores [1]. The general acidification has been widely used due to its short construction period and low cost. It has become a top priority to determine the various construction parameters that meet the general acidification of oilfields in various oilfields. In recent years, the theory of grey correlation degree and BP neural network theory have been widely used in petroleum engineering. EMEI-M uses neural network to evaluate EOR scheme [2], Rezaian A uses neural network to predict the change of oil-water rheological properties in EOR process [3]; H Jian uses BP neural network to predict EOR potential [4]. However, no one has combined these two to optimize the acidification construction prediction. This paper combines the above two methods for the first time, and analyzes the acidification construction.

During the acidification construction of the injection well and the post-measurement analysis, the parameters are divided into three categories, artificially controllable parameters, uncontrollable parameters of the formation, target parameters. The artificially controllable parameters are construction pressure, construction times and volume of single injection, etc. The uncontrollable parameters of the formation include the well depth and thickness of the target layer. The target parameter, injection daily increased, is calculated from the former two.
2. Theoretical Basis

2.1. Gray correlation analysis
The grey relational analysis takes “small sample” with “partial information known and partial information unknown as the research object, and extracts valuable information through the generation and development of "partial" known information to realize the description of evolution \[^5\]. During acidification, the flowing of acid in formation, the pores in which the acid enters the formation, etc. are all unknown “partial information”; the construction pressure, construction times, volume of single injection, the depth of the target layer, and the thickness are all known “partial information”. The controllable parameters are regarded as input, and the target parameters such as daily increase are regarded as output, and unknown information such as acid flow characteristics are not discussed. The degree of gray correlation between input and output is obtained by MATLAB program.

2.2. BP neural network
The BP neural network consists of a number of simple information processing units called neurons. Each neuron receives information from neurons before it, and also sends information to other neurons. Usually the neuron node function selects S Function, such as formula (1)\[^6\].

\[
f(x) = \frac{1}{1 + e^{x}}
\]

(1)

The artificial controllable parameters, the uncontrollable parameters of the formation and the target parameters are respectively used as input and output data at the training period. The mathematical logic of the smallest error can be found by training the existing data of the acidification. When the training is completed and the error of the BP neural network is small enough, it is used to predict the controllable parameters and the target parameters.

2.3. Applied basic data
parameters of acidification such as XL10-95, XL10-96, XL10-105, XL10-141, XL10-154, etc. are used to calculate the number of constructions, construction pressure, volume of single injection, construction displacement, etc., as shown in Table 1 below.

Table 1. Basic data table for acidification construction

| Well   | Injection daily increased (m³) | Construction pressure (MPa) | Construction times (time) | Volume of single injection (m³) | Construction displacement (m³/min) | Layer depth (m) | Layer thickness (m) |
|--------|-------------------------------|-----------------------------|---------------------------|-------------------------------|-----------------------------------|----------------|------------------|
| XL10-95| 6.73                          | 35                          | 1                         | 80                            | 0.8                               | 3106.6         | 4.3              |
| XL10-96| 8.28                          | 35                          | 2                         | 85                            | 0.8                               | 3097           | 4.2              |
| XL10-105| 3                             | 38                          | 1                         | 60                            | 1.0                               | 3173.8         | 3.3              |
| XL10-141| 7.29                         | 34                          | 2                         | 45                            | 0.9                               | 3155.4         | 3.24             |
| XL10-154| 11.4                          | 25                          | 1                         | 50                            | 0.7                               | 3185.2         | 3.28             |

3. Gray Correlation Model
Correlation degree was set through matlab software, and import the construction parameters of each well. Then, the correlation between parameters and target parameter was find, as shown in Table 2.

Table 2. Acidification correlation table

| Influencing factor          | Correlation |
|-----------------------------|-------------|
| Construction pressure       | 0.8064      |
| Construction times          | 0.6170      |
| Volume of single injection  | 0.6131      |
| Construction displacement   | 0.7194      |
| Layer depth                 | 0.6360      |
| Layer thickness             | 0.5805      |
In Table 2, the larger the numerical value, the closer the degree of association. The correlation between construction pressure and injection daily increased is 0.8064, and it indicating that construction pressure has the greatest impact.

4. Sample Application

4.1. Basic situation of Y63-190

Y63-190 is a water injection well. The initial pressure of injecting is 28.79MPa, and the injection of water volume is 24.8m³ every day. But the pressure is increased to 30.16MPa in 2018, and the injection of water volume is 23.6m³ every day.

4.2. Optimization of construction parameters

The depth of the target layer is 2086m and the thickness is 27.8m. According to the grey correlation analysis, the construction pressure has the greatest impact to injection daily increased. Firstly, the construction pressure is predicted. It is assumed that the construction time is 1; the volume of single injection is 70m³, the construction displacement is 0.9m³/min. Calculating the numerical value of injection daily increased when construction pressure is 25, 27, 29, 31, 33, and 35 MPa independently, the input matrix is shown in Figure 1.

$$R_1 = \begin{bmatrix} 25 & 27 & 29 & 31 & 33 & 35 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 70 & 70 & 70 & 70 & 70 & 70 \\ 0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\ 2806 & 2806 & 2806 & 2806 & 2806 & 2806 \\ 27.8 & 27.8 & 27.8 & 27.8 & 27.8 & 27.8 \end{bmatrix}$$

Figure 1. Construction pressure Optimization Matrix

The matrix is inputed into the BP neural network model, and the figure 2 is obtained. According to this, when the construction pressure is lower than 31MPa, the injection daily increased increases rapidly with the increasing of the construction pressure. When the construction pressure exceeds 31MPa, the increasing is not obvious. Considering the economic and construction effects, the suitable construction pressure is 29-31 MPa.

According to the degree of relevance, the construction displacement, construction times, and volume of single injection are predicted. The prediction method is consistent with the construction pressure prediction. Finally, the suitable construction time is 1; the suitable volume of single injection is 48m³; the construction displacement is 0.7m³/min. The prediction of injection daily increase is 10.25m³.

Figure 2. Construction pressure Optimization Forecast Chart
4.3. Construction of Y63-190
For the Y63-190 well, an acidification construction was carried out. Construction pressure is 30.9 MPa; volume of single injection is 48.6 m$^3$; construction displacement is 0.75 m$^3$/min. After this construction, the effect is obvious. The water injection volume is 34.52 m$^3$ every day, more than 10.92 m$^3$ pre-measurement every day.

5. Conclusion
(1) The gray correlation analysis shows that the correlation between construction pressure and injection daily increased is the largest among the four artificial controllable parameters.
(2) On the basis of the BP neural network model, the optimization of the four artificial controllable parameters is divided into four steps.
(3) The gray correlation analysis and the BP neural network model have expandability. Increasing the artificial controllable parameters can improve the accuracy.

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