CSCanada
Advances in Petroleum Exploration and Development
Vol. 7, No. 2, 2014, pp. 99-101
DOI:10.3968/5137

ISSN 1925-542X [Print]
ISSN 1925-5438 [Online]
www.cscanada.net
www.cscanada.org

The Study and Application of Gray-Orthogonal Wavelet Network Forecasting Mode on Cementing Quality

WANG Tingting[a]; ZHAO Wanchun[b],*; SUN Chengyan[c]; ZHANG Huizhen[a]; SHAO Keyong[a]

[a] School of Electrical Engineering & Information, Northeast Petroleum University, Daqing, Heilongjiang, China.
[b] Key Laboratory of Enhanced Oil and Gas Recovery of Education Ministry, Northeast Petroleum University, Daqing, Heilongjiang, China.
[c] The 9th Oil Production Plant Daqing Oilfield Corp.Ltd , Daqing, Heilongjiang, China.
*Corresponding author.

Supported by China Postdoctoral Science Foundation Funded Project (2014M550180), Youth Science Foundation of Northeast Petroleum University (2013NQ105), The Scientific Research Fund of Heilongjiang Provincial Department of Education (12541090), The Scientific Research Fund of Heilongjiang Provincial Department of Education (12521057), PetroChina Innovation Foundation (2011D-5006-0212), The National Natural Science Foundation of China (51104032), PetroChina Innovation Foundation (2013D-5006-0209), and Academic Backbone of Heilongjiang Province University Youth Support Program (1253G011).

Received 5 May 2014; accepted 24 June 2014
Published online 28 June 2014

Abstract

The interrelated characteristics and the complexity of cementation quality affecting factors are considered, a new method of forecasting cementing quality based on Gray-Orthogonal wavelet network is set up. The method regards some factors affecting the cementing quality as the input parameters of the model, and regards quantifying cementation quality as the output parameter of the model. Evaluating and forecasting the cementing quality of Bei1 block of 20 wells in Daqing Oilfield. The maximum fractional error between forecasting results and actual results is 2.66%. The associated problem of impacting factors is solved by the new forecasting method, and the prediction accuracy of cementing quality is improved. A reliable theoretical basis of cementing operation parameters design and construction program adjustment for new wells in oil field is provided.

Key words: Cement job quality; Gray system; Orthogonal wavelet neural network

Wang, T. T., Zhao, W. C., Sun, C. Y., Zhang, H. Z., & Shao, K. Y. (2014). The Study and Application of Gray-Orthogonal Wavelet Network Forecasting Mode on Cementing Quality. *Advances in Petroleum Exploration and Development*, *7*(2), 99-101. Available from: URL: http://www.cscanada.net/index.php/aped/article/view/5137
DOI: http://dx.doi.org/10.3968/5137

INTRODUCTION

To improve the cement job quality of the past, the study is limited to scattered, partial and single factors. The actual well cementing operation, the factors that affect the quality of well cementing is associated and constrained, making the past that considered only single factor to improve cementing quality research is limited. Therefore, to carry out multi-factor to improve cementing quality is of great value. How to determine the factors and the establishment of an advanced and accurate evaluation of cementing quality prediction model is to optimize the parameters of the factors affecting the value of the premise. In this regard, Wang Qinghua[1] made the use of analytic hierarchy process, established a multi-factor method of judging the quality of cementing obtained several factors affecting the quality of cementing; Lu Heyu, Zhu Yuxi [2,3] proposed neural network prediction cementing quality model, due to untreated interrelated factors led to calculation of "disaster" problem, model calculations workload are large and the actual quality of cementing bias still exist. The author considers the orthogonal wavelet network training method simply to determine the number of hidden layer neurons and the hidden layer and output layer weights, and the scaling function of the orthogonal nature of the right value has a unique solution for advantages, the Gray system can compensate for orthogonal wavelet network model of the characteristics of fuzzy problems, proposed a gray Multi-factor orthogonal wavelet network cementing quality prediction methods. Daqing Oil Field using the new method for cementing quality evaluation of the North one block prediction results show that: new ways to predict and the actual measurement results of cementing quality, the maximum error is only 2.66%, and the calculation speed is high, and it has obvious advantages. New methods to improve the parameter adjustment of cement quality provide a reliable theoretical basis.

1. TOPOLOGY STRCUTION OF MODEL

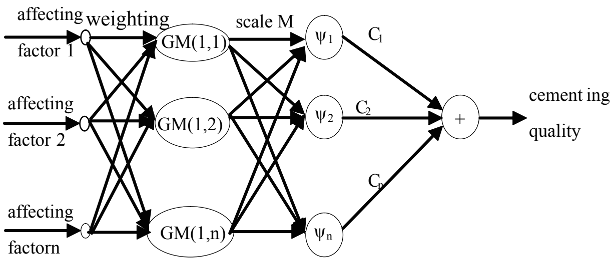

Figure 1
Some Factors Affecting the Cementing Quality Gray-Wavelet Network Forecasting Mode

2. THE THEORY OF MODEL[4,5]

2.1 Aodeling

Set the number of columns of gray system features:

$$X_1^{(0)}=\left(x_1^{(0)}(1),x_1^{(0)}(2),\cdots x_1^{(0)}(n)\right)\text{g} \tag{1}$$

Sequence of related factors:

$$X_2^{(0)}=\left(x_2^{(0)}(1),x_2^{(0)}(2),\cdots x_2^{(0)}(n)\right) \tag{2}$$

$$X_3^{(0)}=\left(x_3^{(0)}(1),x_3^{(0)}(2),\cdots x_3^{(0)}(n)\right) \tag{3}$$

$$X_N^{(0)}=\left(x_N^{(0)}(1),x_N^{(0)}(2),\cdots x_N^{(0)}(n)\right) \tag{4}$$

$X_i^{(1)}$ is the the sequence of 1-*AGO* of $X_i^{(0)}$ (i=1,2,…,N), then the gray system model as follows:

$$x_1^{(0)}\left(k\right)+az_1^{(1)}\left(k\right)=\sum_{i=2}^{N}b_i x_i^{(1)}\left(k\right) \tag{5}$$

Of which:

$$z_1^{(1)}(k)=\frac{1}{2}(x_1^{(1)}(k)+x_1^{(1)}(k-1)) \tag{6}$$

System model simulation values as follows:

$$\hat{x}_1^{(0)}\left(k+1\right)=x_1^{(1)}\left(k+1\right)-x_1^{(1)}\left(k\right) \qquad k=1,2,\cdots,n. \tag{7}$$

Suppose $e(j)=x_1(k)-\hat{x}_1(k) \quad (j=1,2,\cdots n)$ as the residual sequence of gray system, Forecast series is s. Suppose *e*(*j*-1), *e*(*j*-2), ¼*e*(*j*-s) as the orthogonal wavelet network training input samples. e(*j*) serves as a forecast values of expected of orthogonal wavelet network training. Using orthogonal wavelet algorithm, through adequate residual sequence data trains the network, different input vectors correspond to output value. This neural network weighting coefficient, threshold value, and so forth is the network through the adaptive learning of training value. Suppose e(*j*) as orthogonal wavelet network training model prediction of the residual sequence of e(*j*). Construct an arbitrary function, $X(k,j)\in L^2(R)$, If they choose to change the scale of M, Meet:

$$X\left(k,j\right)=\sum_{k=-K}^{K}c_k\hat{X}\left(k,j\right)\psi_{M,j}+\hat{e}(j) \tag{8}$$

Then *X*(*k*, *j*)shall be the predicted value of gray-orthogonal wavelet network prediction model. Which $\psi_{M,j}$ is the orthogonal-scale activation function. *k* is the changes in disturbance interval of the hidden layer nodes. c_k is the output of the network weights. The definition of the network output error is:

$$e_N\left(X\left(k,j\right),\hat{X}\left(k,j\right)\right)=\frac{1}{N}\sum_{i=1}^{N}\left(X\left(k,j\right)-X\left(k,j\right)\right)^2 \tag{9}$$

Use the smallest error of the network weights $\hat{c}_k$ to meet:

$$\hat{c}_k=\frac{\partial_{eN}(X\left(k,j\right),\hat{X}\left(k,j\right))}{\partial c_k}=0 \tag{10}$$

As the scaling function of the orthogonality, for sufficiently large number of training. Cementing quality prediction model has a unique solution, If *k* is very large, Requirements (2*k* + 1) × (2*k* + 1) the inverse matrix of matrix, the calculation is very large. In this paper, iterative gradient reduction method to solve the network to avoid the enormous weight of the inverse matrix, that is:

$$\hat{c}k^{(m)}=ck^{(m-1)}-\lambda\frac{\partial_{eN}(X\left(k,j\right),\hat{X}\left(k,j\right))}{\partial ck}\Big|_{c_k=\hat{c}k^{(m-1)}} \tag{11}$$

Which m means the number of iterations, λ means the iteration step size.

2.2 Solving the Model

Under normal circumstances, orthogonal-scale wavelet network to approach a scale of one-dimensional functions for the 2M, its hidden layer of nodes does not exceed 2M + p, where p ≥ 1 is a small integer. For security, p selects more than one, for close to n-dimensional functions, hidden layer nodes is no more than (2M + p) n. Calculation steps are as follows:

(a) Start a small M, with (2M + p) n to determine the hidden layer nodes;

(b) The use of Equation (5) calculation of the output layer weights, while getting the output of the network of $\hat{X}(k,j)$, N refers to the number of training data;

(c) Calculate the mean square error: $e_N(X(k,j),\hat{X}(k,j))$;

(d) If the error to meet the requirements, then the end; Otherwise, the measure of M increased by 1 and return to 2).

3. APPLICATIONS

Select a block north of Daqing Oilfield known 99 cementing data as learning samples, the block of 20 wells as a model test segment data, evaluate and forecast the

15 days later single-cementing quality. According to a comprehensive evaluation method selected formation pressure coefficient, permeability, borehole enlargement rate, borehole degrees, drilling fluid density, fluid viscosity, cement slurry density, intermediate degrees, displacing speed, the nine kinds of factors affected the quality of cementing as a model of the input layer, using Meyer scaling function as a model of activation function, assuming that the quality of cementing compactly supported function, its sub-set range (0,1), set error is 0.05, changing the scale M = 1. Respectively, neural networks, orthogonal wavelet and gray-evaluation of orthogonal wavelet networks are used to predict, the relative errors of calculation results are shown in Figure 2.

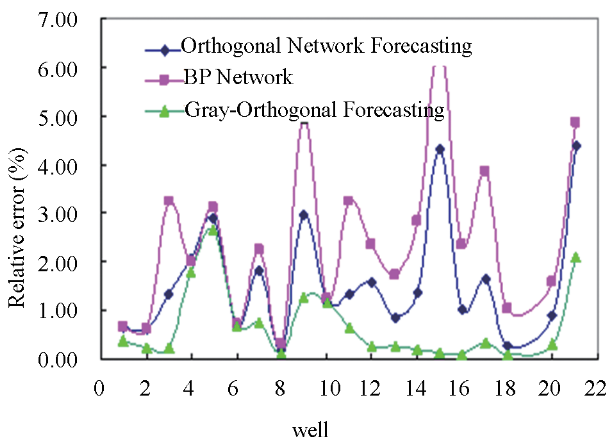

Figure 2
The Evaluate Results of Combination Evaluation Model Compared With the Actual Curve

The results show that three kinds of model calculations. The number of iterations are 5,891, 1,329 and 176. The maximum relative error between models results and actual test results of are 6.87%, 4.39%, 2.66%.

CONCLUSION

Cement quality is affected by geological factors, engineering factors, the impact of factors are interrelated .This paper presents a gray-scale orthogonal wavelet network models to predict the quality of cementing method, a block north of Daqing oil field of 20 wells in the largest prediction error of 2.66%, significantly reduced the number of iterations and the prediction accuracy is high. The new model affect the cementing quality is mainly associated with geological and engineering factors, in order to reasonably determine the cementing operation parameters and the cementing quality prediction provides a feasible approach.

REFERENCES

[1] Wang, Q. H., Mo, J., & Wang, L. (2006). Study estimate methods of cementing quality basing on AHP. *Safety and Technology*, *1*, 67-69.
[2] Lv, H. Y. (2002). Application of neural network in prediction of cementing quality. *Petroleum Drilling Techniques*, *30*(3), 24-26.
[3] Zhu, Y. X., Ni, H. M., & Wang, R. X. (2002). Application of artificial neutral network to forecasting cementing quality. *Journal of Daqing Petroleum Institute*, *26*(2), 52-55.
[4] Wu, B., Yang, Z. P., & Liu, X. C. (2005). Application of grey system in cementing petroleum. *Inner Mongolia Petrochemical Industry*, (12), 121-122.
[5] Zhang, J., & Walter, G. G. (1995).Wavelet neural network for function learning. *IEEE Transaction on Signal Processing*, *43*(6), 1485-1495.