Neural Network Method Applying in Acid Fracturing Choosing Well of Zanarol Oil Field

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Abstract—**In this article, the neural network method is applied to optimize repeated acidizing fracturing Wells. In order to obtain accurate prediction results reverse passing through error and adjust the weights of each layer are adopt. This method applied in Zanarol oil field has got a good effect.**

Keywords- Neural network;acid fracturing; Selected; optimise; carbonatite

I. INTRODUCTION

Zanarol oil field is in the right south 240km of the Aqtobe in the Republic of Kazakhstan. On the regional structure of marina Caspian Sea on the east edge of the basin uplift "a salt under Paleozoic uplift, Oil and gas fields are a set of carboniferous carbonate rock reservoir. Since 2000, Acidizing fracturing technology is widely applied in developing oil field. And has been playing a main role in carbonate gas or oil reservoir stimulation. But acidizing fracturing technology commonly has a definite validity. And relative to the sand fracturing, the validity is usually shorter. Usually quadratic transformation is applied to restore the single well production capacity for failure Wells. So the study against acid fracturing of choosing wells and lays has played a crucial role in improving the effect of modification.

In recent years, International technical services company has carried out a great deal of field experiments and theoretical studies against carbonate reservoir of the key technology of choosing wells and layers, especially direct at the most important method of choosing wells and layers, while the study at this method, Advanced Resources International company, Schlumberger, Intelligent Solutions company, Ely and Associates company, Stem-Lab and Pinnacle technology company etc. have all carried out a large amount of research work. This study has closely combined complex carbonate oil field actual situation overseas, based on the studies of the literature domestic and abroad, Using artificial neural network method, and predicting the well productivity combining with characteristic of the reservoir, So as to realize the carbonate repeated optimization of acid fracturing modification candidate Wells.

Due to the relationship between fracturing effect and its parameters are mostly complex nonlinear. This relationship is difficult to express using traditional mathematical. And due to the different influence degree of each factor on the fracturing effect, and some factors have the phenomenon of crossing influences. Thus of artificial neural network method can be used to solve this kind of highly complicated nonlinear problem. In dealing with this complex nonlinear relationship between the parameters, through the neuron's parameters (the complicated network structure) on the Internet to express knowledge rather than using simple expressions in traditional mathematics. In order to solve the phenomenon of repetition and primary and secondary between parameters by adjusting the network of each node and the connection between the coefficients (the size of the parameters weights).

II. THE BASIC PRINCIPLE OF ARTIFICIAL NEURAL NETWORK

Neural network is a kind of network that consist of using computer hardware or software to simulate the brain networks of neurons and nerve fibers to form a knowledge of complex phenomena. This cognition is not expressed in a simple formula, but in the network on each neuron's parameters and the weight coefficient of fiber, it's using is divided into two stages of learning and application step. In the learning step, users only need to present both a great deal of test data and conclusions (and the result data) to the network. It will complete the learning process automatically.

Adjusting the parameters of the neural network so as to give the correct response to the given data. Since networks are built, it can enter into the application stage, at this time it can deal with the new data, to obtain some results of correct response, and it can also learn something in the process of application, the processing precision of the network depends on the past several experiences gained from the previous learning. Artificial neural network can be used to deal with extremely complex relationships because

of the artificial neural network express knowledge with complex network structure that composed of a large number of neurons. Especially for those phenomenon that have no obvious regularity. The Figure 1 below is the comparison with artificial neural network and the traditional method.
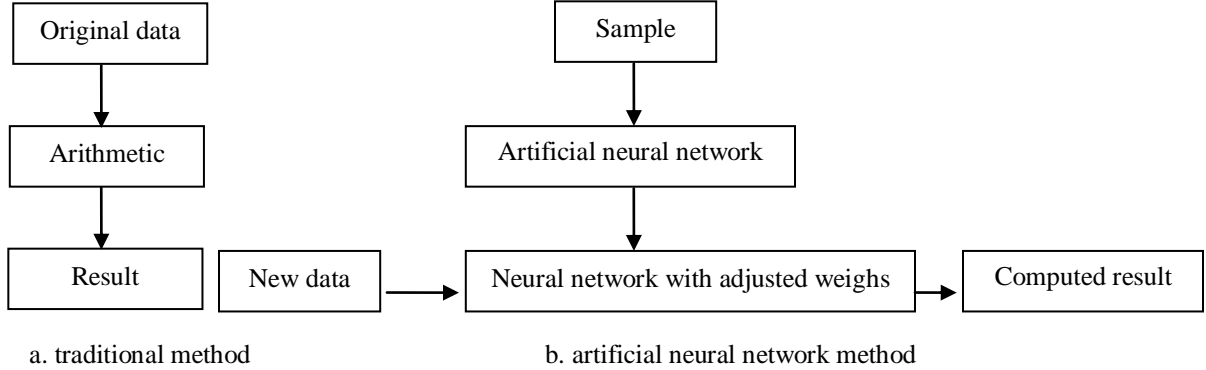

a. traditional method   b. artificial neural network method

Figure 1.   Comparison of traditional method and artificial neural network method

The main characteristic of artificial neural network:

a) Neural network can distribute storing information's information is not stored in a single place but is distributed in different places. A portion of the network does not only store a message, but store in step by step. Even the local network is damaged; the original information can also be restored.

b) The processing and reasoning process of information can be done in the same time.

c) Neural network can process information in the way of self-organizing and self-learning rather than studying and summarizing the regulation of the data in advance. Neurons are the basic component unit of artificial neural network. Each neuron constitutes a complicated network (neural network) in the three-dimensional space. According to the connection pattern of neurons in the neural network, neural network can be divided into two basic types: layered network and mesh network.

III. MATHEMATICAL MODEL OF ARTIFICIAL NEURAL NETWORK

BP neural network include of input layer, interface layer (hidden layer) and output layer. It is connection between the up and down level, while there is no connection between each layer of neurons. After a pair of learning samples is provided to network, the activation values of neuron transmit from the input layer through each layer to the output layer and each neuron network in the output layer gains the input response. According to reduce the target output and the actual error direction, amending each connection weight from the output layer to each layer correction, step by step, and finally returned to the input layer. The accuracy of the impact of network on the input mode has increased with amending the error constantly. And a basic neural model should include R inputs and each input connects to neurons through an appropriate weight.

The BP neural network is composed of input layer, hidden layer and output layer, and own n, m, l neurons respectively, as shown in Figure 2.
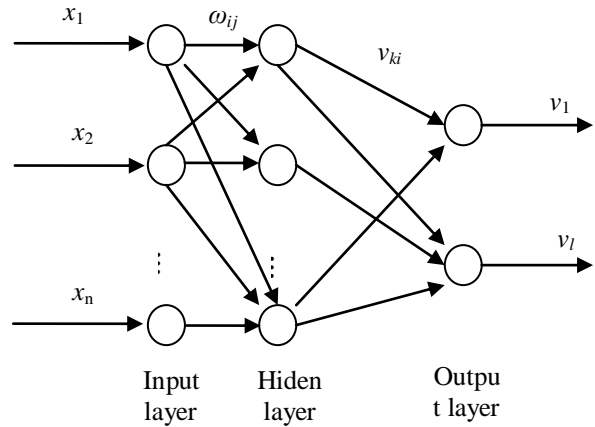

Figure 2.   Neural network model

It has P training samples, setting the input of the pth (p=1, 2, …, P) sample is $x(p)=(x_1(p), x_2(p), …, x_n(p))$,it`s actual output is $t(p)=(t_1(p), t_2(p), … , t_l(p))$,the network output is $y(p)=(y_1(p), y_2(p), …, y_l(p))$. The training steps are as follows:

A. *Positive-going Calculation*

Calculate the input I_{ip} of each neuron in hidden layer.

$$I_{ip} = \sum_{j=1}^{n}\left(w_{ij}x_{jp}\right)+\theta_i$$

The output O_{ip} of neurons in hidden layer.

$$O_{ip} = f(I_{ip}) = \frac{1}{a+be^{-cI_{ip}}}$$

The output y_{kp} of neurons in output layer.

$$y_{kp} = \sum_{i=1}^{m}\left(v_{ki}O_{ip}\right)$$

Where:

w_{ij} ——the bottom-up weight of hidden layer neuron

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$i(i=1,2,\ldots,m)$ and input layer node j;

x_{jp}——the j input value of the p sample;

θ_i——the biases of hidden neuron i;

f——the excitation function of hidden neuron;

a,b,c——adjustable parameters, generally 1;

v_{ki}——the bottom-up weight of output layer neuron $k(k=1,2,\ldots,l)$ and hidden layer neuron i.

B. Back Propagation Algorithm

We define network output error dp and sample error function ep as follow respectively:

$$d_p = t_{kp} - y_{kp}$$

$$e_p = \frac{1}{2}\sum_{k=1}^{l}\left(t_{kp} - y_{kp}\right)^2$$

Where:

t_{kp}——the k actual output value of the p sample;

y_{kp}——the k network output value of the p sample.

Let $W=[w,\theta,v]$, the correction of W: $\Delta W=[\Delta w_{ij},\Delta\theta_i,\Delta v_i]$, in the back-propagation algorithm, along with the direction of the negative gradient of the error function e_p, changing with W, ΔW revise W.

$$\Delta W^{(p)} = -\eta\frac{\partial e_p}{\partial W} + \alpha\Delta W^{(p-1)}$$

Where:

η——learning rate, the range is $[0,1]$, generally 0.02~0.3;

α——momentum factor, the range is $[0,1]$, generally 0.30~0.95.

$$\Delta v_i = \eta d_p\frac{\partial y_p}{\partial v_i} = \eta d_p O_{ip}$$

$$\Delta\theta_i = \eta d_p\frac{\partial y_p}{\partial q_i} = c\eta d_p v_i O_{ip}(1-aO_{ip})$$

$$\Delta w_{ij} = \eta d_p\frac{\partial y_p}{\partial w_{ij}} = c\eta d_p v_i O_{ip}(1-aO_{ip})x_{jp}$$

$W+\Delta W\to W$ is used to revise original bottom-up weight vector W into forward calculation of learning sample $p+1$.

Energy function E after finishing training of P learning samples is defined as:

$$E = \sum_{p=1}^{p}e_p = \frac{1}{2}\sum_{p=1}^{p}\left(t_p - y_p\right)^2$$

If the value of E can meet the demand of some precision value (training error), then stop iteration, or continue another new round iterative calculation.

IV. BP ALGORITHM STEPS

The steps of BP algorithm are shown in Figure 3, as follows:

The first step, the network initialization, the very bottom-up weight is assigned to a random number of interval of (1, 1), the error function e is set, the calculation precision value ξ and maximum learning times M are determined.

The second step, the k input sample and the corresponding desirable output are randomly selected.

The third step, the input Iip and output Oip of each hidden layer neuron are calculated.

The fourth step, the network desirable output and actual output are used to calculate partial derivatives of the error function to the output layer neurons.

The fifth step, the bottom-up weight of the hidden layer to the output layer, partial derivatives of the output layer neurons and output of the hidden layer are used to calculate partial derivatives of the error function to the hidden layer neurons.

The sixth step, partial derivatives of the output layer neurons and output of the hidden layer neurons are used to revise the bottom-up weight.

The seventh step, partial derivatives of the hidden layer neurons and input of the output layer neurons are used to revise the bottom-up weight.

The eighth step, a global error E is calculated.

The ninth step, we judge whether the network error can meet the precision demand. When the error reaches the preset precision value or learning times is larger than the set maximum M, then the algorithm terminates. Otherwise, next learning sample and corresponding desirable output are selected, and return to the third step, and continue next round learning.
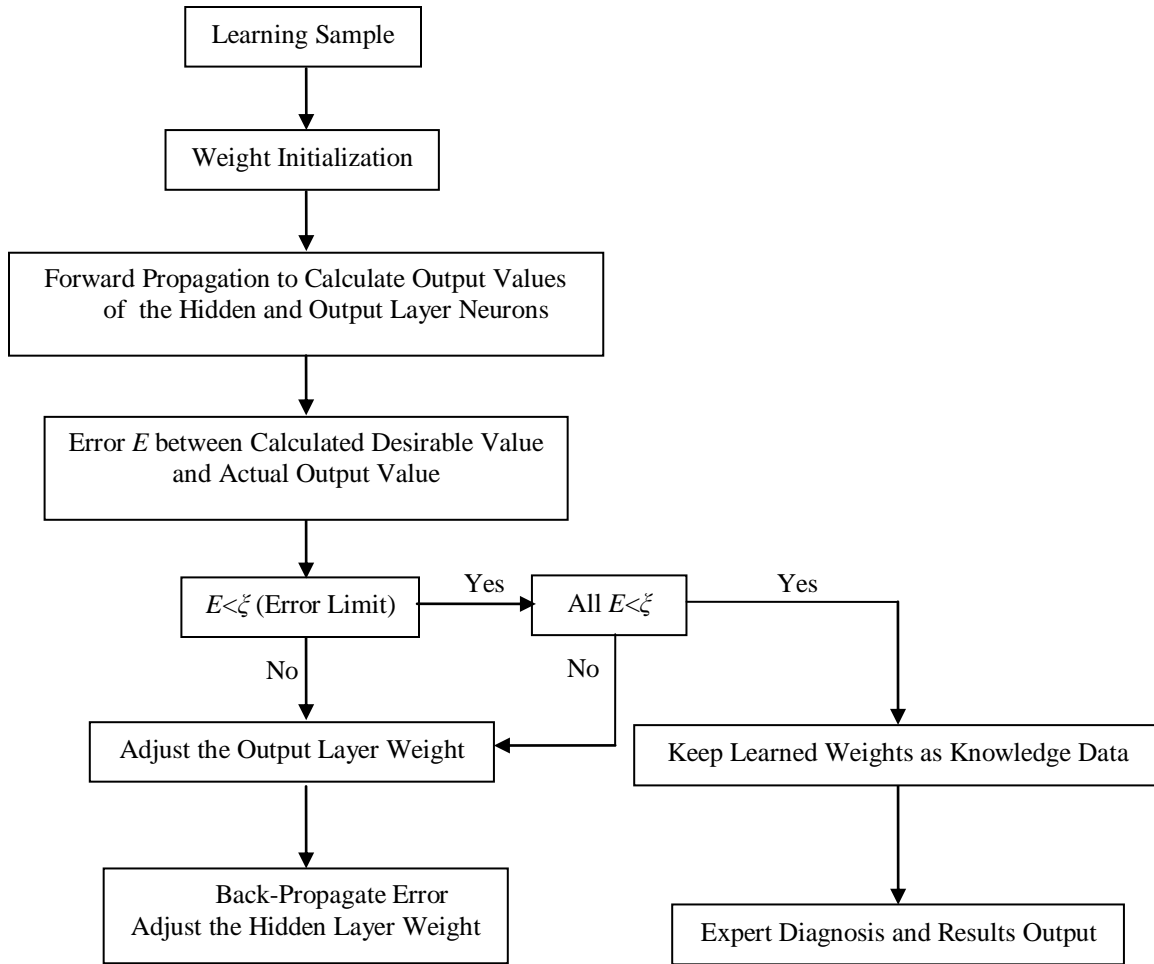
Figure 3.   Learning Diagram of BP Algorithm

V.   ACTUAL APPLICATION

For 6 acid fracturing wells of Zanarol Oilfield, yield prediction of 6 wells is conducted (Table 1), permeability, porosity, oil saturation, effective thickness, acid dosage are selected, the current yield is considered as input sample, the prediction yield after fracturing is considered as output sample. The results show that the prediction results of artificial neural network and the actual production data are basically consistent, achieving good prediction effect.

TABLE I.   YIELD PREDICTION AFTER ACID REFRACTURING TREATMENT OF ZANAROL OILFIELD

Well NO.	Permeability $(10^{-15}m^2)$	Porosity (%)	Oil Saturation (%)	Effective Thickness (m)	Acid Dosage(m^3)	Current Yield (t/d)	Yield Prediction (t/d)
2092	2	12	76	65	234	3	54.42
2449	6	12.03	72.72	44	266.5	13	73.78
3324	29.41	8.79	78.98	16.6	210	8	73.03
3477	8	11.02	78	8	116	6	9.86
3561	14.33	10.78	87.39	37.6	221.3	17	22.75
3563	8.99	10.07	79.13	21.2	228	14	21.78

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