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# Dynamic prediction of gas wells based on feedback artificial neural network

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**Abstract.** Sudong gas wells vary hugely in production capacity, and meet extremely complex situation in dynamic changing. In view of Sudong gas wells with such characteristics, dynamic prediction of gas wells based on feedback artificial neural network is helpful to improve the exploitation productivity and management efficiency of the gas wells. In this paper, a prediction system based on feedback artificial neural network is developed, which can be used for analysis of dynamic changes of gas wells, forming gas well geological parameters and prediction model for production decline. The reliability, rationality and practicability of the prediction system are guaranteed through full verification and comparison of the predicted results.

## 1. Introduction

Gas well dynamic prediction<sup>[1]</sup> is an important part of gas reservoir engineering, and the core work of oil and gas well exploitation and management. It is also an important basis for formulating reasonable exploitation plans and conducting technical and economic evaluation. Therefore, dynamic prediction methods and model selection have great influence on the accuracy of gas well exploitation. Researchers worldwide usually make gas well productivity curves based on data from single well tests, and continuously explore mathematical models and solution of gas well productivity under various gas reservoir conditions to obtain efficient exploitation measures. In recent years, the prediction technology based on artificial neural network has been widely used in various fields, especially in the prediction of geology and productivity evaluation of oil and gas wells<sup>[2-5]</sup>. Developing a prediction system based on feedback artificial neural network for gas well dynamic prediction has theoretical and economic benefits.

The controllable reserves of Sudong' Shanggu gas wells are small, the sand body size varies

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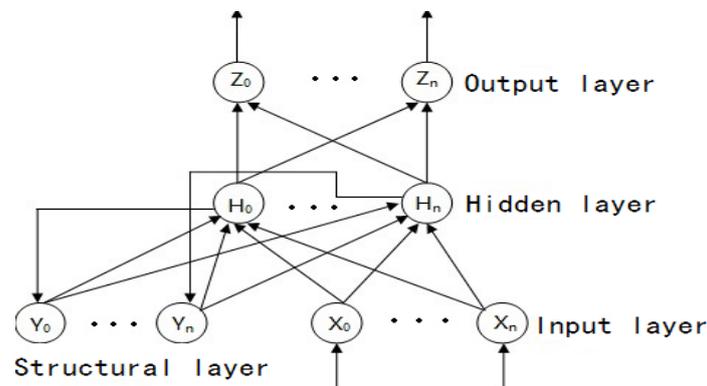
About the Author: Yi-lin Duan, woman, be born 1964, Senior engineer, Mainly engaged in oil and gas layer engineering development research.



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greatly, and the gas reservoir heterogeneity is obvious<sup>[6]</sup>. Xiagu gas wells are affected by the ablation groove of the reservoir, and their dynamic features are extremely complicated. It is difficult to develop a reliable geology model and to form complete representation with empirical prediction methods, which results in poor prediction results for conventional gas reservoirs. Practice has proved that the best solution for predicting such gas reservoir is using feedback artificial neural network. Compared with the classification method and empirical regression method for gas well dynamic prediction, the prediction based on feedback artificial neural network is more accurate and more reliable. The developed neural network model and prediction system are decoupling and can be modified separately. It's suitable for serving oil and gas well exploitation in a long-term period.

As is known to all, according to the relationship between the purpose and the input data, artificial neural network mainly solves the following three problems: prediction, discriminant classification, and pattern recognition. Feedback neural network structure is shown in Figure 1, which is composed of multiple input and output layers. After receiving the input vector  $X$  from the input layer, the vector  $H$  is calculated and passed to the hidden layer. There may be multiple hidden layers, through which vectors are calculated and passed to the output layer  $Z$ . The input of each neuron may be affected by previous output of the neuron. Such network is called a feedback neural network<sup>[7]</sup>. Feedback neural network improves the sensitivity of network to historical data, enhances the network's ability to process dynamic information, which is more conducive to develop gas well dynamic prediction models.



**Figure 1** feedback neural network structure

## 2. Gas well dynamic feature identification index

### 2.1. Daily production report of gas well

Table 1 shows the daily production report data of a single well in Sudong' Shanggu gas wells. As can be seen from the table that the longer time the gas well is exploited, the greater amount of data will be recorded<sup>[9]</sup>. The key problem to be solved by dynamic feature identification is that how to select several simple eigenvalues to represent the gas well production capacity summarized in the huge data of a single well production daily report, to compare the new production daily report to be identified with the simulated samples quickly and accurately, to find the most similar sample. This is the first step to predict production capacity of unknown well using the single well simulation results.

**Table 1** Sample list of individual well production daily reports

Date	Well	Production time	Oil pressure (MPa)	Nesting pressure (MPa)	Daily gas production (104m <sup>3</sup> )	Nissan water volume (m <sup>3</sup> )
2008-8-22	SuDong 43-43	24	2.60	17.40	0.8492	0
2008-8-23	SuDong 43-43	18	2.60	17.40	0.8853	0
2008-8-24	SuDong 43-43	21	2.70	17.00	0.8205	0
:	:	:	:	:	:	:

### 2.2. Dynamic feature identification index

In this paper, four dynamic feature indexes<sup>[8-9]</sup> are selected to identify the single well daily production report in different wells.: weighted average of casing pressure(weighted average of casing pressure per day and gas production per day of n days), well opening rate (in n days), average daily gas production (the cumulative daily gas production in n days divided by the number of production days converted by t); the average daily water production(similar to average daily gas production). It should be noted that the actual data of the fitting wells in this paper are all 0.

From the perspective of production capacity of gas wells, daily gas production reflects the physical properties of gas wells(mainly refers to the permeability), while daily water production reflects the water contained in the gas well. Weighted average of casing pressure reflects the gas storage capacity of gas wells. Well opening rate reflects the strength of gas wells and the recovery degree of closed wells since exploiting. These indexes reflect the elastic energy of a single well controlling sand body.

### 2.3. Calculation of dynamic feature identification index

With these four indexes, the capacity and declining speed of gas wells can be easily compared and identified, and the dynamic capability of gas wells can be evaluated. The larger daily production, the larger total production of wells, the larger weighted average of casing pressure, the stronger capacity of stable production, the higher well opening rate, the smoother the production situation of wells are. Actually, weighted average of casing pressure and well opening rate can be multiplied as an index for convenience. These four identification indexes for can be easily calculated by writing a program from gas well daily production reports.

## 3. Geological parameter prediction of Artificial neural network

In geological parameters, dynamic reserves and permeability are the main parameters that directly reflect the dynamic data of gas well production. The variables—effective thickness, porosity, and saturation—are subordinate to dynamic reserves, and these variables can only be predicted constrainedly if dynamic reserves is predicted. Therefore, dynamic reserves and permeability are the key parameters of artificial neural network prediction. Effective thickness, porosity and saturation are secondary parameters.

Table 2 shows the geological parameters as the training samples of artificial neural network, which is a vector consisting of the 143 wells' geological model parameters and each well's dynamic feature

identification indexes. The training samples are divided into observation part and target value part, between which there has causality. Artificial neural network training is to adjust the weights of each neuron in the neural network, forming a neural network model suiting the training samples.

**Table 2** Training samples of artificial neural network for predicting geological parameters of Shanggu gas wells

Sample well ID	Sample observation			Sample target value					
	Weighted sleeve pressure× Opening rate	Converting gas (104m <sup>3</sup> )	Converting daily water (104m <sup>3</sup> )	Stratum	Dynamic reserve (104m <sup>3</sup> )	Effective thickness	Porosity	saturation	Permeability
SD43-43	15.25	0.8	0.0	box 8	0.0954	6.6	10.3	58.4	0.609
				mountain 1	0.0438	2.8	9.5	68.5	0.417
				mountain 2	0.0	0.0	0.0	0.0	0.0
:	:	:	:	:	:	:	:	:	:

After training, the gas well dynamic feature identification index is used to predict the physical properties such as the dynamic reserves and permeability of gas wells, to carry out targeted exploitation and management, and to improve the productivity of gas wells. The following prediction example is based on the dynamic identification indexes of the daily production reports of a gas well since the exploitation on September 1, 2011 (at t=200×24 hours), weighted average of casing pressure is 10.38MPa, well opening rate is 0.85, daily gas production is 12,000 square meters per day, and the daily water production is 0. The geological parameters predicted by neural network are shown in Table 3.

**Table 3** Example of the predicted geological parameters

Stratum	Dynamic reserve	Effective thickness	Porosity	Gas saturation	Permeability
	108m <sup>3</sup>	m	%	%	m
box 8	0.0533	2.6	11.5	60.5	0.620
mountain 1	0.0367	2.1	9.0	65.4	0.365
mountain 2	0	0	0	0	0

#### 4. Artificial neural network for predicting dynamic ARPS of gas wells

The training samples of artificial neural network for predicting dynamic ARPS of gas wells are shown in Table 4. The training sample is a vector consisting of the ARPS decline parameters of 143 wells<sup>[10-12]</sup> and each well's dynamic feature identification indexes. After training, the ARPS decline parameters listed in the target value part of the sample are obtained, and the predicted ARPS decline parameters of the Sudong \*\* well are listed as shown in Table 5.

**Table 4** Training samples of artificial neural network for predicting dynamic ARPS decline of Shanggu gas wells

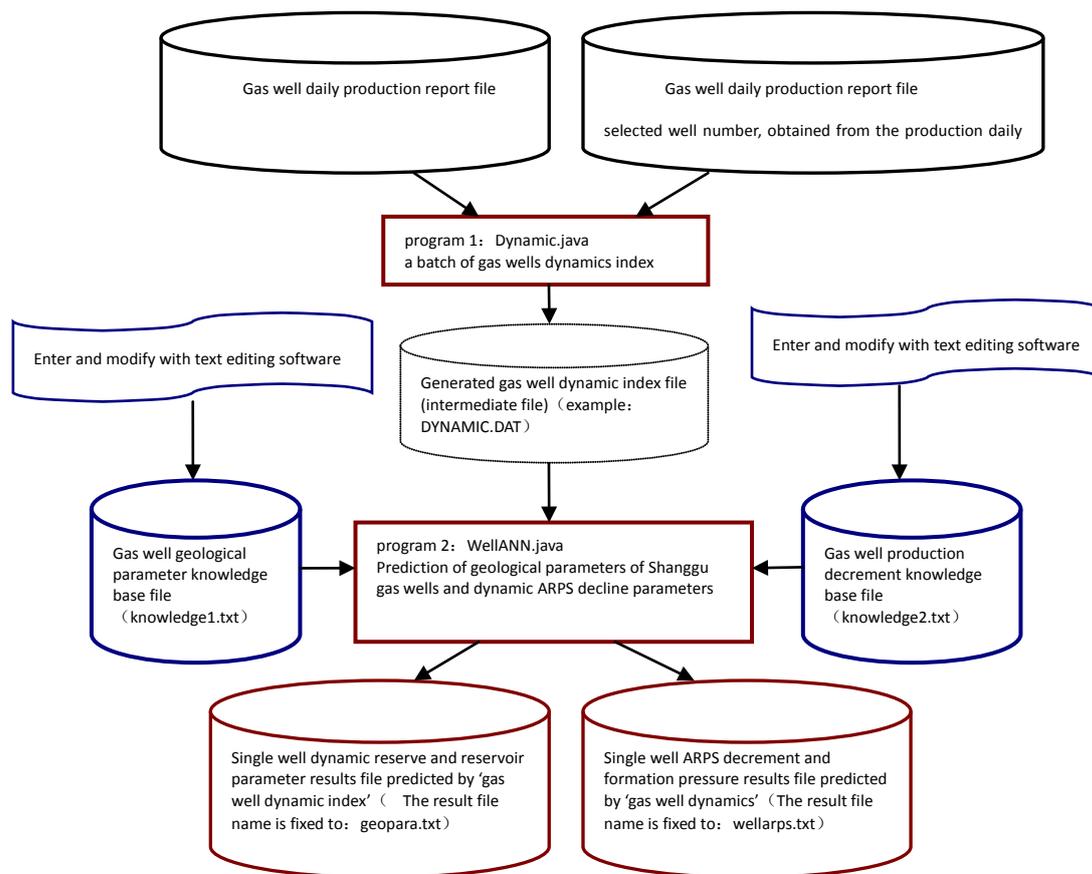
Sample well name	Sample observation			Sample target value			
	Weighted sleeve pressure× Opening rate	Converting gas (104m <sup>3</sup> )	Converting daily water (104m <sup>3</sup> )	Initial formation force (MPa)	Initial production (104m <sup>3</sup> )	Monthly decline rate (%)	Dynamic reserve (104m <sup>3</sup> )
Su Dong 23-53	16.2	2.4	0	27.5	3.5	3.4	3250
Su Dong 27-38	8.1	0.7	0	25.8	0.8	2.7	940
Su Dong 28-55	15.3	2.5	0	27.6	2	3.5	1890
:	:	:	:	:	:	:	:

**Table 5** \*\* Example of the predicted ARPS decline parameters for \*\* wells

Production time(month)	Daily output (104m <sup>3</sup> )	Declining cumulative production (104m <sup>3</sup> )	Formation pressure (MPa)
0	0.71	0.0	26.3
1	0.70	21.3	26.0
2	0.69	42.4	25.7
3	0.68	63.2	25.4
4	0.67	83.7	25.1
5	0.66	104.1	24.9
6	0.66	124.1	24.6
:	:	:	:

## 5. Prediction system based on Artificial neural network

The prediction system based on feedback artificial neural network for predicting geological parameters and ARPS decline parameters in this paper is designed and developed on Java and C++, the system structure is shown in Figure 2. The prediction system can be connected to the network database of gas wells to predict and analyze the required gas well data locally. The reliability, rationality and practicability of the prediction system are guaranteed through full verification and comparison of the predicted results. The predictive system has practical significance and worth popularizing.



**Figure 2** Structure of prediction system based on artificial neural network for predicting geological parameters and ARPS decline parameters

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