Application of Fracturing Well Selection Method in C Oilfield

Yuxi Zhao [1], Haiyu Yang [2]

[1]Northeast Petroleum University, Heilongjiang Daqing, 163000, China

[2]Daqing Oilfield Co, Heilongjiang Daqing, 163000, China

Abstract

With the deepening of oil field development, fracturing is a necessary way to obtain industrial oil output in petroleum reservoir exploitation.in order to ensure the oil well fracturing effect and economic benefits,to improve the coincidence rate of the oil well fracturing scheme,and to avoid the empirical and blindnesss of traditionally fracturing well selection,according to the practices of well fracturing selection in recent years, fracturing well selection method which is suitable for C oil field was established by using fuzzy mathematics method , that is The fuzzy evaluation analysis method. The computation result of the model is very consistent with the result of the region's actual fracturing construction. The research achievement lays a foundation for sustainable development of C oil field, to guide fracturing well selection is of great significance

Keywords

fracturing; fuzzy evaluation; well selection

1. Current fracturing conditions of C oil field

So far, C oil field has fractured 1433 wells,which were 35.4% of total oil Wells. Measure well increases oil production played an important role in the C oil field development. Since the "11th five-year plan", accumulative total to deflection fracturing 323 wells, the average single well oil increase quantity was 279 t/a with good efficiency of oil production increase. However, the single well oil increase quantity dropped to 238t/a in 2011 from 387 t/a in 2006. The effect of measure well weakened obviously. The water cut of crude oil in oil field increased continuously with oil production, the casing-damaged wells increased greatly. Two times or three times above fracturing well number increased. The thickness of the fracturing potential oil well was thin and its reservoir property was getting worse and worse. And in the process of oil field development, the difficulty of selecting well increased further. In order to solve the problem of potential small of measures well in recent years,every year fracturing 100～110 wells ensured the measure well oil increase quantity reached(2.0～3.0)$\times 10^4$t.In order to guarantee the fracturing effect, further improve the economic benefit, it is necessary to analyze the factors influencing the fracturing effect, choose suitable fracturing for wells, set up oil well fracturing effect forecast model.

2. Evaluation of fracturing well potential

2.1 Determine the weight of factors influencing the fracturing effect

Analytic hierarchy process (AHP) is particularly suited to solving some decision problems of the comparatively complicated structure and quantifing difficult multi-objective (multi-criteria) ,which was put forward by operational researcher SAATY at the University of Pittsburgh in the 1970 s. Concrete operation steps using AHP are as follows[1]:

1）Based on relations among the various factors influencing fracturing well selection , distinguish between the different levels.

2) Pairwise comparison, determine the comparison matrix.To clearly determine the comparative matrix, according to methods of scale, various factors as rows and columns of the matrix, respectively, then comparing between every two factors have done and determine the calibration of all factors by using the intrasystem unified scale. AHP determine the unified scale of the comparative matrix as shown in table 1.

Tab.1 Scale of AHP

Scale	Implication
1	Compared to two elements have the same importance
3	An element is slightly more important than another element
5	An element is obviously more important than another element
7	An element is strongly more important than another element
9	An element is extremely more important than another element
2	Two phase judgment mean-value between 1 and 3
4	Two phase judgment mean-value between 3 and 5
6	Two phase judgment mean-value between 5 and 7
8	Two phase judgment mean-value between 7 and 9
Reciprocal	Factor i-to-j importance ratio is Pij, The ratio of the importance of the factors and factors is $P_{ji}=1/P_{ij}$

3) Building equivalence matrix

Comparative matrix sometimes does not meet the judgment consistency, to avoid this problem, using the optimal transfer matrix improve comparison matrix and make it satisfy the requirement of consistency.

$$\boldsymbol{C}_{ji} = \lg \boldsymbol{P}_{ji} \tag{1}$$

Above formula: P_{ji} is comparison matrix; C_{ji} is comparative matrix after the logarithmic transformation.

$$d_{ij} = \sum_{i=1}^{N} (C_{ik} - C_{jk})/N, \tag{2}$$

Above formula: N is the number of elements in comparison matrix.

Next, one exponent calculation, as shown in formula (3).

$$P_{ij}^{*} = 10^{d_{ij}} \tag{3}$$

P_{ij}^{*} as judgment matrix consistent and complete equivalence with P.

4)Weights are calculated by the identified square root of the equivalent matrix, as shown in type (4)

$$\overline{W_i} = \sqrt[n]{\prod_{j=1}^{n} P_{ij}^{*}},\ i=1,2,\ldots,n \tag{4}$$

Then, $\overline{W_i}$ is standardized.

$$W_i = \frac{\overline{W_i}}{\sum_{k=1}^{N} \overline{W_k}}, \tag{5}$$

$W_i=[W_1,W_2,\ldots,Wn]T$, the relevant elements in the layer.that is the weight of each influence factors compared to the upper layer.

5) Calculating the total weight of various factors

If the upper layer has m factors, its weight value respectively is:a_1、a_2, ..., am, the weight of n factors of this layer A1, A2,..., An, compared to various factors of the upper layer is Wi_1、Wi_2, ..., Win（i=1,2,3…..m）, then the total weight of the factors in this level is Σm1＝1 a iWi_1, Σmi ＝1Σmi＝aiW_{in}.

So, eventually all weights of affecting factors can be calculated by one layer from top to bottom in turn.

2.2 Theory of optimizing fracturing wells fuzzy comprehensive evaluation model

Using The fuzzy relationship principle ,fuzzy evaluation analysis method make the overall evaluation to optimizing fracturing wells after fully considering and evaluating in advance the influence of various relevant factors.The basic methods and steps are as follows[2]：

1）Setting up the factor set affecting fracturing effect

The factor set is a common set composed of the various factors affecting and evaluating optimizing fracturing Wells. is generally indicated by the letter U., namely:

$$U = \{u_1, u_2, \ldots, u_m\} \quad (6)$$

All the factors that affect the fracturing effect is represented by each factor Ui(i=1, 2..., m), However, all the factors has some extent ambiguous. In this study, when judging whether the well is suitable for fracturing, A collection of these factors is the factor set,such as effective thickness、connecting direction number、The moisture content before pressure、 flush production、recovery percent,ect.

For example, N influence factors in i well need to classification, Marked as:

$$u_i = (u_{i1}, u_{i2}, \ldots, u_{in}) \quad (7)$$

In this way, the sample set can be determined by using the fuzzy matrix for describing the characteristics of the factors affecting ,Marked as:

$$U = (u_{ij})_{n\times m} \ (i = 1, 2, \ldots, n;\ j = 1, 2, \ldots, m) \quad (8)$$

2) Calculation method of the utility function

There are very big difference to describe the physical quantity of the characteristics of the factors affecting,but,we only need the quantitative analysis in order to avoid the interference of the physical quantity in classified counting[3]. Therefore, we need to normalize the eigenvalues of influence factors for each well with the use of utility function. In this paper, the method is as follows:

For the bigger and the optimal factor index, the calculation of the utility function is as follows:

$$b_{ij} = \frac{u_{ij}-(u_{ij})_{min}}{(u_{ij})_{max}-(u_{ij})_{min}}, \quad (9)$$

Above formula: U_{ij} is the value of the jth influence factor belonging to the ith well.（Uij）min is the minimum value of the jth factor in all wells,（Uij）max is the maximum value of the jth factor in all wells; b_{ij} is the corresponding value of the jth influence factor belonging to the ith well after being normalized by using the bigger and the optimal factor index.

For the smaller and the optimal factor index, the calculation of the utility function is as follows:

$$b_{ij} = 1 - \frac{u_{ij}-(u_{ij})_{min}}{(u_{ij})_{max}-(u_{ij})_{min}} \quad (10)$$

b_{ij} is the corresponding value of the jth influence factor belonging to the ith well after being normalized by using the smaller and the optimal factor index. Thus we can get the utility function matrix B:

$$B = [b_{ij}]_{n\times m} \quad (11)$$

Above formula: n is the number of wells; m is the number of influence factors; b_{ij} is the corresponding value of the jth influence factor belonging to the ith well after being normalized .B is the utility function matrix[4].

Based on the weight matrix of the various factors influencing the fracturing effect W=[W1,W2,…….,Wn]T and the utility function matrix B of the various influence factors, The comprehensive utility value of each well is:

$$\mathrm{E} = \sum_{j=1}^{n} W_j b_{ij} \tag{12}$$

Above formula: b_{ij} is the corresponding value of the jth influence factor belonging to the ith well after being normalized;Wj is the weight of the jth influence factor; is the comprehensive utility evaluation value. The larger the E , the better the fracturing effect.so, fracturing wells can finally be chosen by ranking list of E from big to small.

3. Case analysis

Taking a class of block block in C oil field for example, factors affecting fracturing effect have effective thickness、connecting direction number、moisture content before pressure、flush production、recovery percent.in this paper, layers of AHP is only one layer for determining the weight of the influence factor,then, the comparison matrix first need to be determined which make up of various influencing factors in this block. As shown in table 2.

Tab.2 Comparison matrix

factor	effective thickness	connecting direction number	moisture content before pressure	flush production	recovery percent
effective thickness	1	2.0	2.0	0.5	2.0
connecting direction number	0.5	1	2.0	0.5	2.0
moisture content before pressure	0.5	0.5	1	0.33	0.5
flush production、	2.0	2.0	3.0	1	2.0
recovery percent	0.5	0.5	2.0	0.5	1

Then, weights of various factors are obtained through AHP, as shown in table 3.

Tab.3 Weights of the factors

Factor	Effective Thickness	Connecting Direction Number	Moisture Content Before Pressure	Flush Production	Recovery Percent
Weight	0.2375	0.1254	0.0289	0.542	0.0662

According to the principle of fuzzy evaluation, all of the single well comprehensive evaluation index is obtained by analyzing the fractured well in this block and sequenced from big to small. This kind of block single-well factors affecting results as shown in table 4.This kind of block single-well statistical sorting result as shown in table 5.

Tab.4 Date of influeneing factors of fracture well

Well Name	Effective Thickness/m	Connecting Direction Number/number	Moisture Content Before	Flush Production/t	Recovery Percent/%

			Pressure/%		
J1	19.20	1	0.00	3.6	2.56
J2	24.00	1	37.60	5.2	27.81
J3	14.80	3	7.00	8.0	32.22
J4	22.00	2	12.00	8.7	31.96
J5	12.40	4	19.50	10.2	34.70
J6	11.40	2	2.10	4.2	32.53
J7	11.80	2	14.40	1.8	7.78
J8	11.20	3	2.40	3.5	5.20
J9	7.00	2	0.90	4.0	10.33
J10	9.40	2	3.00	4.2	8.77
J11	12.20	2	5.00	9.0	24.94
J12	11.80	2	6.00	3.9	26.33
J13	19.80	3	30.00	6.2	11.47
J14	15.80	1	96.00	5.7	10.15
J15	21.00	2	15.00	5.2	9.12
J16	6.90	4	28.00	3.9	30.36
J17	18.40	4	32.00	4.8	25.86
J18	12.00	2	20.00	5.9	33.25
J19	9.40	3	23.00	8.5	19.74
J20	12.80	2	20.00	5.8	13.71
J21	12.80	2	12.00	0.0	9.01
J22	10.00	2	28.20	6.0	34.10
J23	11.60	1	14.00	5.8	14.40
J24	18.80	2	16.00	5.9	8.54
J25	18.80	2	0.00	5.9	2.22

Tab.5 Sequence result of fracture wells

Well Name	Comprehensive Evaluation Index	Well Name	Comprehensive Evaluation Index	Well Name	Comprehensive Evaluation Index
J5	0.7668	J17	0.5775	J10	0.3805
J4	0.7447	J2	0.5454	J16	0.362
J13	0.6594	J20	0.4976	J12	0.3612
J3	0.6503	J14	0.4765	J6	0.3602
J11	0.6409	J1	0.4565	J9	0.334
J19	0.6225	J18	0.452	J7	0.2849
J25	0.6157	J23	0.4395	J21	0.2014
J24	0.598	J22	0.4253		
J15	0.5905	J8	0.4176		

4. Conclusion

1）Using AHP determined the weights of the main factors of impacting on the effect of oil increase after pressure and different influence factors on the fracturing effect;

2)Through Using processing method of the utility function, the data of the influence factor of fracturing can eliminate the influence of physical units;

3) The model of selecting well for optimizing fracturing were established by using the fuzzy evaluating method.

Reference

[1] Hemanta Mukherjee. A Parametric Comparison of Horizontal and Vertical Well Performance. SPE, 1991.

[2] Hujunli. A New Method to Predict Performance of Fractured Horizontal Wells. SPE7051, 1996.

[3] Jasti J K. Use of Analytical Solutions to Improve Simulator Accuracy. SPE55225, 1999.

[4] Penmatcha V R. A Comprehensive Reservoir/Wellbore Model for Horizontal Wells. SPE55225, 1998.