Application of Center Approximation Ideal Point Method in Evaluation of Well Pattern Encryption Effect

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Abstract. Since 1996 the research of well pattern infilling technology has been developed in seventy three blocks of Daqing peripheral oilfields. In order to evaluate the development effect of infilling blocks, this paper improved the normalized method and computational method of the distance between every filling plan and the positive ideal plan in the TOPSIS with interval-valued weight. The indexes which can evaluate development effect of infilling blocks were given in this paper, and part of the infilling blocks of Chaoyanggou oilfield were evaluated by the integrated approach of ideal point solution. The integrated approach of ideal point solution is not only a new quantitative method but also the theoretical foundation and technical support to evaluate the development effect of infilling blocks.

1. Center Approximation Ideal Point Method

Note a=[a-, a+]={x|a-≤x≤a+, a-≤a+}, call a an interval number, let λ be an arbitrary real number, and define the quantity multiplication of λ and a= [a-, a+] as follows: when λ is greater than 0, λ [a-, a+]=[λ a-, λ a+]; when λ is less than 0, λ [a-, a+]= [λ -a-, λ -a-].

The concrete operation steps of the central approximation ideal point method in the development effect evaluation of well pattern infilling block are as follows:

Suppose there are m encryption schemes, n evaluation indicators, the weight of evaluation index Fj cannot be determined completely, but it knows w_j∈[c_j, d_j], where 0≤c_j≤d_j≤1, j=1, 2, ……n, w_1+w_2+……+w_n=1, the index value of encryption scheme Xi under the jth evaluation index Fj is a_ij, i=1,2……m.

Step 1: The decision matrix A=(a_ij)m*n is normalized, and the normalized decision matrix B=(b_ij)m*n is obtained. At present, there are five common attribute types of indicators: effective benefit type, cost type, fixed type, interval type and deviation type. Benefit type attribute refers to the attribute whose value is larger and better. Cost type attribute refers to the attribute whose value is smaller and better. Fixed type attribute refers to the attribute whose value is closer to a fixed value a* and interval type attribute refers to the attribute whose value is closer to a fixed interval. The better attributes, and deviated attributes refer to attributes whose values deviate from a fixed value p* the better.

(1) Indicators of benefit-oriented attributes, orders:

$$b_{ij} = \frac{a_{ij} - \min_{1≤i≤m}a_{ij}}{\max_{1≤i≤m}a_{ij} - \min_{1≤i≤m}a_{ij}}$$ (1)
(2) Indicators of cost attributes:

\[ b_{ij} = \frac{\max_{1 \leq i \leq m} a_{ij} - a_{ij}}{\max_{1 \leq i \leq m} a_{ij} - \min_{1 \leq i \leq m} a_{ij}} \]  

(3) Indicators of fixed attributes, orders:

\[ b_{ij} = \begin{cases} 1 & a_{ij} = a^* \\ 1 - \frac{a_{ij} - a^*}{\max_{1 \leq i \leq m} a_{ij} - a^*} & a_{ij} \neq a^* \end{cases} \]  

(4) Indicators for interval attributes:

\[ b_{ij} = \begin{cases} 1 - \frac{q_1 - a_{ij}}{\max(q_1 - \min a_{ij}, \max a_{ij} - q_2)} & a_{ij} < q_1^* \\ 1 & a_{ij} \in [q_1^*, q_2^*] \\ 1 - \frac{a_{ij} - q_2^*}{\max(q_1 - \min a_{ij}, \max a_{ij} - q_2)} & a_{ij} > q_2^* \end{cases} \]  

(5) Indicators of deviating attributes:

\[ b_{ij} = \begin{cases} \frac{|a_{ij} - p^*|}{\max_{1 \leq i \leq m} |a_{ij} - p^*|} & a_{ij} \neq p^* \\ 0 & a_{ij} = p^* \end{cases} \]  

Step 2: Construct weighted interval number standardized decision matrix \( C = ([c_{ij}, c_{ij}^+])_{m \times n} \). Where \([c_{ij}, c_{ij}^+]=[b_{ij}, c_{ij}, b_{ij}^+, c_{ij}^+], i=1, 2, \ldots, m; j=1, 2, \ldots, n.\)

Step 3: Determine the positive ideal scheme \( X^+ \) and the negative ideal scheme \( X^- \). order:

\[ t_j^* = \max_{1 \leq i \leq m} c_{ij}^- \quad t_j^+ = \max_{1 \leq i \leq m} c_{ij}^+ \]

\[ s_j^* = \min_{1 \leq i \leq m} c_{ij}^- \quad s_j^+ = \min_{1 \leq i \leq m} c_{ij}^+ \]  

The regular ideal scheme \( X^+ \) is: \( X^+ = ([t_1^*, t_1^+], [t_2^*, t_2^+], \ldots, [t_n^*, t_n^+]) \)

Negative ideal scheme \( X^- \) is: \( X^- = ([s_1^*, s_1^+], [s_2^*, s_2^+], \ldots, [s_n^*, s_n^+]) \)  

2. Evaluation Index of Development Effect of Well Pattern Infilling Adjustment

The evaluation index of oilfield encryption effect mainly includes three categories: development technology, production management, economic benefit and more than 40 indexes. According to the comprehensive evaluation criterion of waterflooding development effect based on grey system theory, combined with the actual factors affecting the infilling effect of Chaoyanggou oilfield, and using the methods of logic analysis and expert experience comprehensively, this paper will optimize the reservoir control and utilization, water flooding status, oil recovery speed, water cut change, energy conservation and utilization, and economic benefits after infilling. The evaluation index is used to evaluate the encryption effect. Eight evaluation indexes of encryption effect are screened out to improve the oil recovery rate multiple, the change of comprehensive decline rate, the degree of water
drive control, the degree of water drive, the change of water cut rise rate, the increase of recovery rate, the change of formation energy maintenance level and the internal benefit rate after tax\cite{1-7}.

3. An Example of Application of Center Approximation Ideal Point Method is Given

Based on the principle of different reservoir types, different encryption modes and longer encryption time, nine typical blocks are selected in 27 encryption blocks of Chaoyanggou Oilfield. The encryption modes and development data of each encryption area are shown. This paper will introduce the application method of the central approximation ideal point method in the evaluation of the development effect of the encrypted area by taking these nine encrypted blocks as examples.

The steps of the central approximation ideal point method in evaluating the development effect of some encrypted blocks in Chaoyanggou Oilfield are as follows:

(1) The normalization of decision matrix A (a_{ij}) 9*8 is processed, and the normalized decision matrix B (b_{ij}) 9*8 is obtained.

\[
\begin{array}{cccccccc}
0.12 & 1.00 & 0.00 & 0.66 & 0.00 & 0.00 & 0.66 & 1.00 \\
0.05 & 0.59 & 0.33 & 0.25 & 0.21 & 0.35 & 0.66 & 0.59 \\
0.41 & 0.55 & 0.60 & 0.41 & 1.00 & 0.96 & 0.94 & 0.28 \\
0.10 & 0.00 & 0.62 & 0.21 & 0.49 & 1.00 & 0.74 & 0.44 \\
0.00 & 0.57 & 0.56 & 1.00 & 0.65 & 0.80 & 1.00 & 0.36 \\
1.00 & 0.47 & 0.27 & 0.37 & 0.60 & 0.41 & 0.00 & 0.75 \\
0.41 & 0.57 & 0.47 & 0.60 & 0.45 & 0.45 & 0.75 & 0.72 \\
0.00 & 0.57 & 0.63 & 0.44 & 0.58 & 0.78 & 0.28 & 0.00 \\
0.10 & 0.68 & 1.00 & 0.00 & 0.62 & 0.95 & 0.78 & 0.60 \\
\end{array}
\]

(2) Constructing weighted interval number standardized decision matrix \( C = ([c_{ij}^+, c_{ij}^-])_{9 \times 8} \)

\[
\begin{array}{cccccccc}
0.012,0.031 & 0.050,0.100 & 0.000,0.000 & 0.033,0.099 & 0.000,0.000 & 0.000,0.000 & 0.033,0.066 & 0.020,0.056 \\
0.005,0.013 & 0.029,0.059 & 0.033,0.082 & 0.012,0.037 & 0.004,0.011 & 0.053,0.088 & 0.033,0.066 & 0.012,0.016 \\
0.041,0.141 & 0.028,0.055 & 0.060,0.151 & 0.020,0.066 & 0.20,0.059 & 0.144,0.241 & 0.047,0.094 & 0.006,0.014 \\
0.010,0.026 & 0.000,0.000 & 0.062,0.155 & 0.010,0.031 & 0.010,0.024 & 0.150,0.250 & 0.037,0.074 & 0.009,0.022 \\
0.000,0.000 & 0.028,0.057 & 0.056,0.141 & 0.050,0.159 & 0.013,0.032 & 0.120,0.200 & 0.050,0.100 & 0.007,0.018 \\
0.100,0.250 & 0.023,0.047 & 0.027,0.068 & 0.019,0.056 & 0.012,0.030 & 0.061,0.102 & 0.000,0.000 & 0.015,0.037 \\
0.044,0.182 & 0.029,0.057 & 0.047,0.118 & 0.030,0.091 & 0.009,0.022 & 0.068,0.113 & 0.038,0.075 & 0.014,0.016 \\
0.000,0.000 & 0.028,0.057 & 0.063,0.158 & 0.022,0.066 & 0.012,0.029 & 0.116,0.194 & 0.014,0.028 & 0.000,0.000 \\
0.010,0.026 & 0.034,0.068 & 0.100,0.250 & 0.000,0.000 & 0.012,0.031 & 0.143,0.238 & 0.039,0.078 & 0.012,0.030 \\
\end{array}
\]

(3) Positive ideal scheme \( X^+ = (a_{ij}^+, b_{ij}^+) \)

\[
X^+ = ((0.10,0.25],[0.05,0.10],[0.10,0.25],[0.05,0.15],[0.02,0.05],[0.15,0.25],[0.05,0.10],[0.02,0.05])
\]

(4) The distance \( d^+_i \), the distance \( d^-_i \), the proximity \( C_i \) of each scheme to the positive ideal scheme and the development effect of each encryption block are listed. From the evaluation results, it can be seen that the encryption effect of the second block is the best, the encryption effect of the third block is the general, and the encryption effect of the first block is the worst.

4. The Analysis of the Development Data of Nine Encrypted Zones

The first kind of block has a later infilling time, higher recovery degree before infilling, higher comprehensive water cut, lower daily oil production and higher water cut at the initial stage of infilling well, and little increase in oil production rate and recovery rate after infilling. The improper adjustment of injection-production system results in lower water drive control degree and lower multi-directional connectivity ratio in infilling area. The comprehensive analysis results show that the infilling effect of the first kind of block is poor.

Before infilling, the recovery degree of the second type block is not high and the comprehensive water cut is low. By infilling, the well pattern direction is better adapted to the fracture direction. The initial daily oil production of infilled wells is high and the water cut is low. Most blocks have a longer effective period. The oil recovery rate and recovery rate of the block are greatly improved. The injection-production system is adjusted in time. The degree of water drive control and the production
status of the reservoir are obviously improved. The comprehensive analysis results are as follows: Class II block encryption effect is good.

By infilling adjustment, the well spacing is further reduced, the injection pressure and injection-production pressure difference are reduced, the establishment of effective drive system between oil and water wells is promoted, and the pressure holding condition is alleviated. However, due to the limitation of its own geological conditions, the infilling effect of the three types of reservoirs is not as good as that of the second type reservoirs.

The above analysis results are consistent with the evaluation results of the development effect of the encrypted blocks in Chaoyanggou Oilfield by the central approximation ideal point method. Therefore, the central approximation ideal point method can be used as a new evaluation method to quantitatively evaluate the development effect of the encrypted blocks.

5. Conclusion

By introducing the number multiplication operation of interval numbers, the problem of multi-index decision making with interval numbers as weights is transformed into the problem of selecting interval numbers as indexes. The method of determining the optimal block in multi-index decision making with interval numbers as weights is studied, i.e. the method of center approaching ideal point, and the quantitative method of evaluating the development effect of well pattern infill blocks is given. The evaluation system of development effect of well pattern infilling adjustment block is given, and the development effect of some infilling blocks in Chaoyanggou Oilfield is evaluated by the method of center approaching ideal point. The evaluation results show that the infilling effect of type II reservoir is the best and that of type I reservoir is the worst in Chaoyanggou oilfield. Comparing the evaluation result of the central ideal approximation point method with the analysis result of the development data of encrypted blocks, it is considered that the method is accurate in evaluating the development effect of encrypted blocks, and can be used as a new evaluation method for quantitative evaluation of the development effect of encrypted blocks.

6. References

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