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## Research Article

# Comprehensively evaluation of alkali-surfactant-polymer flooding recovery percent

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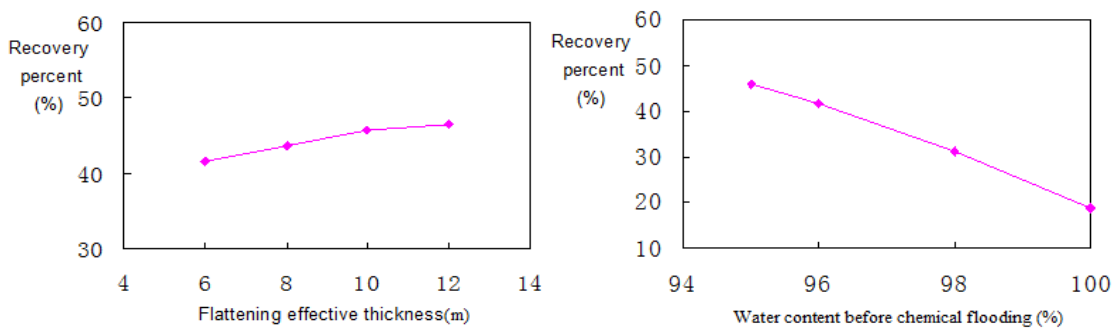
**Abstract:** Comprehensively analyze the factors affecting recovery percent of alkali-surfactant-polymer flooding and utilize ridge-formed distribution function to conform degree of membership to each evaluation factors. And then establish comprehensive evaluation models of alkali-surfactant-polymer flooding recovery percent in order to assess the recovery percent effect of second reservoir by ASP. Results show that this method has a certain significance for guiding recovery effects of oil blocks.
**Keywords:** ASP; fuzzy math; recovery percent; comprehensively evaluation method

## INTRODUCTION

As the largest ASP flooding industrial field test in China, B1 region of Daqing oilfield has achieved a significant increase in enhancing oil recovery[1-2] and ASP flooding will become the leading development measure in Daqing oilfield as a consequence. ASP flooding means injecting a mixed solution of alkali, surfactant and polymer, these 3 chemicals [3,4] of which the EOR(Enhanced Oil Recovery) mechanism is reducing mobility, reducing oil/water interfacial tension, improving sweep efficiency and altering rock wettability [5]. Factors affecting ASP flooding recovery percent is numerous and complicated. In this paper, we raised an effective method to evaluate ASP flooding recovery percent by using fuzzy math which can solve multivariate fuzziness, uncertainty and difficult quantify to find out the ASP flooding applicability in class II reservoirs according to test data from one block of B1 region.

## OPTIMIZING EVALUATION INDEXES

We defined affecting factors of ASP flooding recovery percent by numerical simulation as shown in figure 1, among them, flattening effective thickness, degree control of chemical flooding, usage of chemicals and concentration of injection are positive correlation to recovery percent while permeability variation coefficient and water content before chemical flooding are negative correlation to recovery percent [6]. Then include these 6 indexes into the evaluation system about ASP development effectiveness.



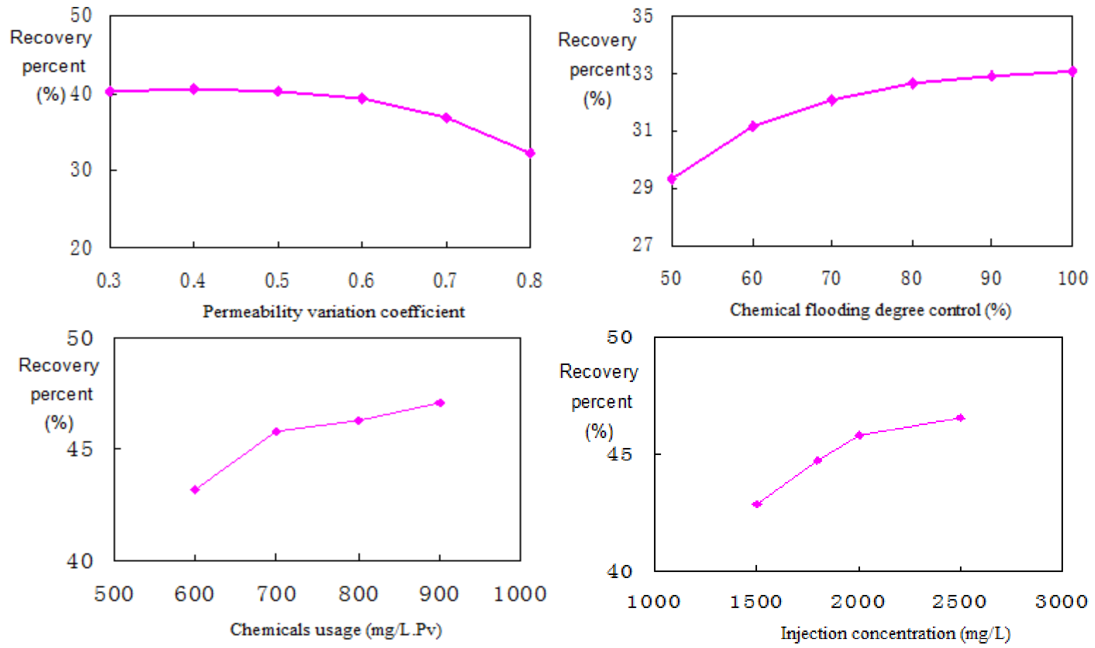



**Fig-1 Factors mainly affecting ASP**

## EVALUATED METHOD OF RECOVERY PERCENT

Factor set to the fuzzy evaluation system of ASP recovery percent is $Y=\{y_1,y_2,\cdots y_n\}$, n=6, whose factors are flattening thickness, degree control of chemical flooding and others. Judge set is $V=\{v_1,v_2,\cdots v_m\}$, m=3, namely (class A well group, class B well group, class C well group) [7,8]. To judge single factor $y_i$ ( i=1, 2, …, n) , we can get fuzzy sets about V and form a judgment space ( Y, V, R[9].

On the basis of maximum membership principle, we use ridge-formed distribution function to definite membership function. Due to the different levels of development to various factors, we expressed weight distribution by fuzzy set $W=\{w_1,w_2,\cdots w_n\}$, among them,

$$W_i = P_i / \sum_{k=1}^{n} P_k, \quad P_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}^*} \qquad (1)$$

Analyzing the former 6 factors by SPSS PASW Statistics which is integrated system using for analyzing data. Compared influential degree of each factor through output correlation matrix, namely concentration of injection > usage of chemicals > permeability variation coefficient > degree control of chemical flooding > water content before chemical flooding > flattening effective thickness.

Utilizing analytical hierarchy process [10] to certain the weight of each factor and inducting scales 1~9 to construct judgment matrix so that we can obtain eigenvector corresponding to largest latent root of matrix, namely the weight $a_{ij}^*$, which satisfies the principle of consistency.

Finally, we calculate membership of excellent program in system by means of fuzzy optimization model, namely the optimized membership degree of program. Due to the principle of maximum membership, we can obtain the optimal schedule of program.

$$u_j = \frac{1}{1+\dfrac{\sum_{i=1}^{m}\left(W_i\left|r_{ij}-g_i\right|\right)^2}{\sum_{i=1}^{m}\left(W_i\left|r_{ij}-s_i\right|\right)^2}} \qquad (2)$$

## APPLICATION

We researched one certain block's ASP development effects in B1 region of Daqing oilfield by using fuzzy comprehensive evaluation method. The whole area is about 1.92 $km^2$ and the productive object is class II reservoirs. Based on effective thickness $H_e$ of perforating channel and connecting directions, single well group is divided into A, B, C 3 classes by means of classified analysis and then evaluate the recovery percent respectively[11].

Class A well group: monolayer perforating channel sand $H_e \geq 4$m and a class of connectivity of channel sand≥2 directions;

Class B well group: monolayer perforating channel sand $H_e < 4$m and whole well channel sand $H_e \geq 4$m;

Class C well group: whole well channel sand $H_e$<4m.

Affected factors of each well group are shown as follows:

**Table-1: Well set parameters using for comprehensive evaluation**

| Factors Well group | Positive correlation | | | | Negative correlation | |
|---|---|---|---|---|---|---|
| | Fattening thickness(m) | Chemical flooding degree control(%) | Chemicals usage(mg/L.PV) | Injection concentration (mg/L) | Water content before chemical flooding(%) | Variation coefficient |
| Cass A | 6 | 50 | 1500 | 1800 | 95 | 0.6 |
| Cass B | 10 | 80 | 1600 | 2000 | 90 | 0.5 |
| Cass C | 8 | 75 | 1800 | 1600 | 97 | 0.7 |

According to maximum membership and consistency principle, we get membership matrix through ridge-formed distribution function:

$$R = \begin{bmatrix} 0 & 1 & 0.50 \\ 0 & 1 & 0.83 \\ 0 & 0.33 & 1 \\ 1 & 0.50 & 0 \\ 0.29 & 1 & 0 \\ 0.50 & 1 & 0 \end{bmatrix}$$

Recovery percent weight of each factor calculating by formula (1):

$W=(W_1, W_2, \ldots, W_n)^T=(0.365, 0.164, 0.064, 0.041, 0.100, 0.266)^T$

From formula (2), we know the membership degree of each class arranged as follows: $u_2>u_3>u_1$, namely class B well group of recovery percent is the best.

$U=(0.098, 0.991, 0.325)^T$

Figure3 describes contrast curve of recovery percent and water content and obviously the development effect of class B well group is much better than class A and class C. Fuzzy evaluation results match the practice.

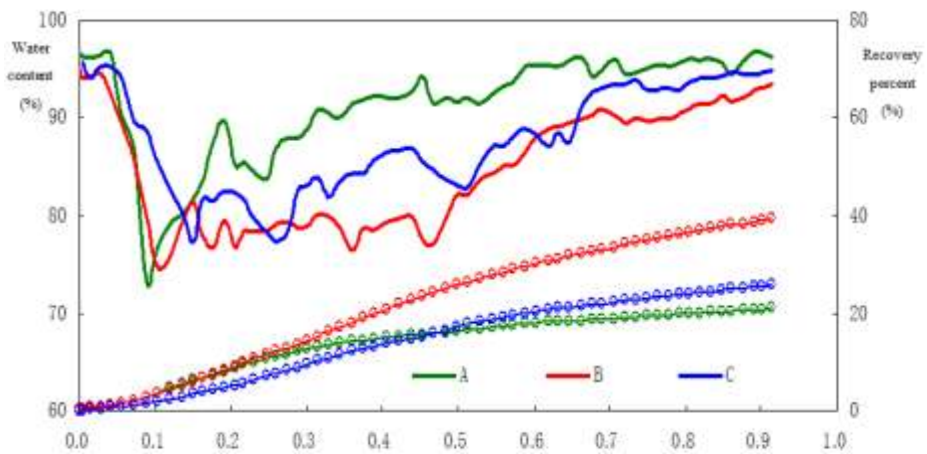



**Fig-3 Comparison of recovery percent and water content**

## CONCLUSION

ASP is a enhanced oil recovery technology with considerable prospect [12]. What's more, the recovery percent to the ASP flooding industrial field test in B1 region of Daqing oilfield is expected to increase 19.5% by contrast of water flooding. The comprehensive evaluation model of ASP recovery percent on the basis of fuzzy evaluation and analytical hierarchy method has a certain significance, considering 6 affected factors. During the process of evaluation, the method eliminated man-made subjectivity and avoided homogeneity. Simultaneously the final result is consistent with reality so this method can be utilized to apply to evaluate recovery percent of other reservoirs.

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