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Research on Influence Factors of ASP Flooding and Prediction of Water Containing Pattern

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Abstract
ASP flooding is one of main ways for oilfields to enhance oil recovery, but it needs to further research which slug parameters of ASP flooding are important factors influencing oil recovery. Taking a pilot zone as example, by designing scheme with orthogonal design method to conduct numerical analog calculation, analyzing data with grey correlation and multiple regression, it concluded that dosage of main slug, concentration of polymer, concentration of surface active agent and auxiliary slug are main factors influencing oil recovery; combining these factors to predict water containing rule can obtain water containing rule prediction formula with higher accuracy to meet requirements on site.

Key words: ASP flooding; Oil recovery; Influence factor; Water cut prediction

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INTRODUCTION
ASP flooding is widely used in oilfields as tertiary oil recovery efficiently enhancing oil recovery. There are many researches on influence factors of ASP flooding, Li Huabin, Wu Wenxiang[1], Wang Keliang, Liao Guangzhi[2] and Xia Huifen[3], and so on, which have conducted corresponding research in this aspect. This paper summarized previous research of others, determined experimental scheme, determined parameters of chemical flooding with larger influence on oil recovery with grey correlation method, and determined quantitative relation of these main influence parameters to minimum water cut and PV number corresponding to minimum water cut to predict water cut according to the prediction formula[4].

1. ESTABLISHMENT OF IDEAL MODEL
Based on actual geological parameters of oilfield, establish ideal model of single well group to research influence of chemical dosage and concentration of different slugs on oil recovery. The model is a five-point areal pattern, with gridding of 15×15×6, step length of plane gridding being 20 m, step length of longitudinal gridding being 3 m, 4 m, 4 m, 5 m, 7 m, and 10 m; depth of oil deposit being 850 m. Permeability of single layer is 159 mD, 465 mD, 523 mD, 486 mD, 638 mD and 790 mD respectively; after blank water flooding reaches 90%, start three compound combination flooding till to water cut reaches 98%.

2. ORTHOGONAL SCHEME DESIGN
Main parameters considered are pre-slug dosage and polymer solution concentration, main slug dosage, polymer solution concentration, alkali concentration and surface active agent concentration, auxiliary slug dosage, polymer solution concentration, alkali concentration and surface active agent concentration, protective slug dosage and polymer solution concentration of ASO combination flooding. Set 3 levels to stimulate for each factor, specifically see Table 1. Total 27 schemes are designed to conduct numerical stimulation using ideal model for each scheme and calculate corresponding oil recovery, thus conduct analysis according to stimulated result.

Table 1
ASP Combination Flooding Injection Parameter

Factor level	Pre-slug dosage	Pre-slug polymer concentration	Main slug dosage	Main slug polymer concentration	Gauge concen of main slug	Main slug alk concen	Auxiliary slug dosage	Auxiliary slug polymer concen	Gauge concen of auxiliary slug	Auxi slug alk concen	Rear slug dosage	Rear slug polymer concentration
Level 1	0.035	1,300	0.15	1,800	0.25	1	0.15	1,500	0.06	0.8	0.1	600
Level 2	0.05	1,500	0.2	2,000	0.3	1.2	0.2	1,800	0.1	1	0.15	1,000
Level 3	0.065	1,800	0.3	2,200	0.4	1.5	0.3	2,000	0.15	1.3	0.25	1,500

3. DATA ANALYSIS AND PROCESSING

Grey relation analysis mainly includes the following steps:

(a) Conduct normalization processing of original data, eliminating influence of round-off error and dimension in correlation calculation, and avoiding occurrence of unequal weight.

(b) Solve absolute value.

(c) Find maximum and minimum among all independent variables, that is maximum and minimum difference between two poles.

(d) Solve correlation coefficient, degree of correlation is the mean value of correlation coefficient of every independent variable, the larger the degree of correlation, the larger the influence of the variable on dependent variable. Through calculation in these steps, analyze and rank degrees of correlation under different resolution ratio, for specific results see Table 2.

Table 2
Correlation Analysis and Sorting Under Different Resolution Coefficient

Parameters	Degree of correlation					
	$\sigma = 0.5$	Ranking	$\sigma = 0.4$	Ranking	$\sigma = 0.3$	Ranking
Pre-slug dosage	0.057	12	0.049	12	0.038	12
Pre-slug polymer concentration	0.086	11	0.075	11	0.063	11
Main slug dosage	0.675	1	0.641	1	0.598	1
Main slug polymer concentration	0.642	2	0.613	2	0.579	2
Gauge concentration of main slug	0.586	5	0.558	5	0.539	5
Main slug alkali concentration	0.376	7	0.352	7	0.331	7
Auxiliary slug dosage	0.621	3	0.596	3	0.556	3
Auxiliary slug polymer concentration	0.597	4	0.567	4	0.543	4
Gauge concentration of auxiliary slug	0.398	6	0.375	6	0.362	6
Auxiliary slug alkali concentration	0.325	8	0.312	8	0.296	8
Rear slug dosage	0.173	9	0.156	9	0.137	9
Rear slug polymer concentration	0.126	10	0.112	10	0.103	10

Through degree of correlation calculated in the table, the variable with larger degree of correlation is main factor influencing oil recovery, and is also considered main cause influencing other exploring factors such as water cut. Parameters with larger degree of correlation are dosage, polymer concentration, surface active agent concentration of main slug, dosage, polymer concentration of auxiliary slug[5].

4. PREDICTION OF WATER CONTAINING RULE

Through numeral simulation it is found that variation of most water cut appears typical regularity, mainly showing "√-shaped" variation[6]; by analyzing and summarizing the effect character of actual water cut on site, similar rule also is found, for specific shown in Figures 1 and 2.

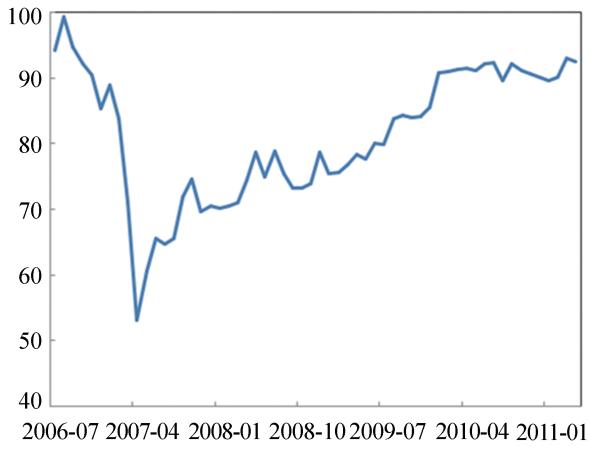

Figure 1
Actual Comprehensive Water Cut Curve (√ Type)

4.1 Water Cut Prediction Formula

Based on orthogonal design numeral simulation scheme, determine quantitative relation of feature points such as minimum of water cut f_d, PV number corresponding to minimum of water cut t_d, initial water cut f_{wo} with five parameters, that is dosage, polymer concentration, surface active agent concentration of main slug and dosage, polymer concentration of auxiliary slug.

4.2 Water Cut Curve

Sine decline of water cut effect:

$$f_w = f_{wo} - 2(f_{wo} - f_d)\sin^2\left(\frac{\pi t}{4t_d}\right).$$

Logarithm pick-up of water cut,

$$f_w = f_d + 6\ln[1+220(t-t_d)].$$

Where f_{wo} is initial water cut, %; f_d minimum water cut; t_d PV number corresponding to minimum water cut.

Based on basic parameters and combining the above quantitative relation, in the pilot zone, resulting calculated water cut f_d = 78.3, actual f_d = 79.9, predicted water cut f_w = 96.5, actual average water cut f_w = 97. Average relative error between actual and predicted water cut is 0.52%.

CONCLUSION

(a) During simulating actual geological conditions, through numeral simulation research using ideal model, by designing scheme with orthogonal design method and processing simulated results with grey correlation, it is concluded that five parameters including dosage, polymer concentration, surface active agent concentration of main slug and dosage, polymer concentration of auxiliary slug are main factors influencing oil recovery.

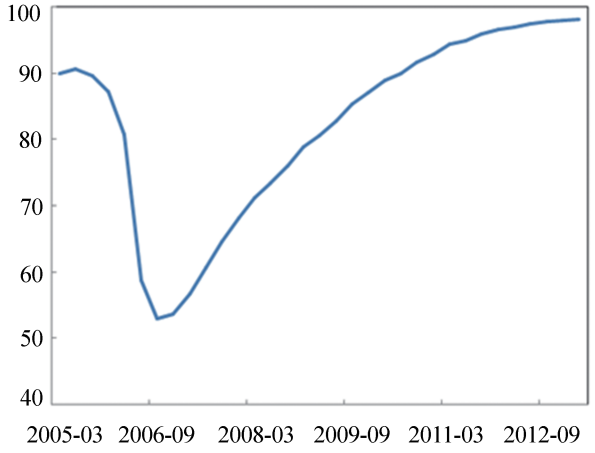

Figure 2
Water Cut Curve of Numerical Simulation

(b) By analyzing variation of actual water cut on site and water cut curve of numeral simulation, it is found that most water cut curves show "√" shape. Find the rule in it to obtain water cut prediction formula which is illustrated to have higher accuracy.

(c) Actual geological conditions are far more complex than that, so when analyzing influence factor and predicting water cut rule, the above method can act as a reference, with actual condition needing specific analysis.

REFERENCES

[1] Wu, W. X., Zhang, D., Kan, L., & Lang, L. Y. (2013). Optimization of alkali agent on performance of ASP system. *Fault-Block Oil & Gas Field*, *6*, 772-774.

[2] Wang, K. L., Fu, T. T., Wang, C. C., & Ming, Y. Y. (2013). Emulsion forming rules of ASP system seepage in porous media. *Oilfield Chemistry*, *1*, 83-86.

[3] Xia, H. F., Yang, Q. Y., Zhang, J. R., & Ma, W. G. (2012). Experimental research on quantitative characterizations of elasticity and viscosity of polymer solution used to displace crude oil. *Experimental Technology and Management*, *7*, 29-31.

[4] Sorbie, K. S. (1990). Depleted layer effects in polymer flow through porous media: I. single capillary calculations. *Journal of Colloid and Interface Science*, *139*(2), 299-314.

[5] Fletcher, A. J. P., Flew, S. R. G., Lamb, S. P., Lund, T., Bjornestad, E., Stavland, A., & Gjovikli, N. B. (1991, February). *Measurements of polysaccharide polymer properties in porous media*. Paper presented at SPE International Symposium on Oilfield Chemistry, Anaheim, California.

[6] Yang, M., Liao, G. Z., Han, P. H., Yang, Z. Y., & Yao, Y. M. (2003, September). *An extended field test study on alkaline-surfactant-polymer flooding in Beiyiduanxi of Daqing oilfield*. Paper presented at SPE Asia Pacific Oil and Gas Conference and Exhibition, Jakarta, Indonesia.