Study on the optimal plug size design of weak alkaline ternary composite driven in block II7-12 of an oilfield A

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Abstract: The weakly alkaline ternary compound drive block in Block A II7-12 oil formation is the first block in an oilfield to adopt the lipopeptide compounded weakly alkaline ternary system for industrial production, and the explored target layer II7-12 belongs to Class IIB+ Class III oil formation. In view of the nature of the oil formation in the block, a study combining indoor physical model rating and numerical simulation was carried out, and the optimization of the size of the extended ternary main and secondary plugs was taken in the process according to the dynamic response at the right time to further improve the recovery rate and increase the economic benefits.

Keywords: Class II B+III reservoir; plug; numerical simulation; enhanced recovery.

1. Basic information about the block

Block A Ⅱ7-12 oil layer weak alkali ternary compound drive block is the first block in an oilfield to adopt the lipopeptide compound weak alkali ternary system for industrial production, the exploitation of the target layer Ⅱ7-12 belongs to class II B + class III oil layer, eighteen positive faults are developed in the block, due to the influence of fault blocking, the number of wells with perfect planar injection and extraction is relatively low, one hundred and twenty-one wells with unidirectional and bidirectional connection, accounting for 48.6% of the total number of recovered wells. The drilling encounter rate of river sand in the block is only 18.2%, with poor reservoir development and high mud content, the average effective thickness of single well development is 7.3m, the effective thickness of single well drilling encounter ranges from 2.2 to 19.8m, different sand bodies are interspersed and the development connection varies greatly.

The design of the plug is based on the experience of the previous Class I and Class II reservoirs and uses the classic plug model: 0.06PV front plug + 0.35PV ternary main plug + 0.20PV ternary secondary plug + 0.20PV subsequent poly-protected plug.

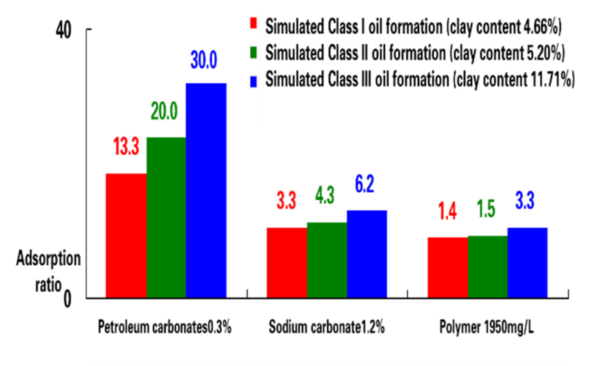
During the development process, the block maintains a good development effect and has the potential for further efficiency improvement. Compared with the northern block, the reservoir development has become worse, but under the same injection pore body conditions, the stage water content and the maximum water content reduction are comparable to the northern block; compared with the earlier South 4 East weak alkaline ternary composite drive block, the water content reduction and the comprehensive water content level are 2.89 % lower, and the water content is reduced by 2.85 % more. Due to the development of faults in the block, the zoning effect is not synchronous and uniform on the plane; there are large differences in the sand bodies on the plane, but there are differences in the effect of the classified well groups, and the subsurface surface-active agent adsorption is not saturated due to the influence of high mud content, which has the potential to further improve the effect.

Table 1 Table of comparison of base data for Class II blocks

Block	Injection and extraction Well spacing (m)	Mining Layer	Effective Thickness (m)	Penetration Rate (mD)	Riversand drilling encounter rate (%)	Controlling degree (%)	High flooding Proportion (%)	Initial water content when injecting aggregation (%)	Maximum water content drop (%)	Water content of the same pore body (%)
Block B	125	II10+11-III	14.1	403	29.02	70.6	27.33	95.46	11.95	86.54
Block C	125	II10+11-III	11.6	384	21.98	67.8	26.48	96.45	9.12	89.12
Block D	110	II7-14	8.3	273	16.6	67.3	53.3	96.01	7.80	91.84
Block A	125	II7-12	7.3	271	18.2	69.44	38.2	93.56	10.65	88.95

2. Indoor physical model test results

Considering the actual development condition and development reality of the II7-12 oil formation in Block A, indoor physical model experiments and numerical simulations were carried out to further optimize the size of the ternary main plug and secondary plug. The indoor core adsorption experiments show that the increase in mud content increases the loss of chemical agent adsorption, among which the loss of surface activator adsorption is the largest. The optimization of increasing the size and concentration of the plugs was carried out for the Class IIB+ Class III reservoirs, in which increasing the amount of primary and secondary plugs could further improve the recovery rate. Based on the research results, the ternary main and secondary plugs were extended moderately for the relatively low water content at the end of the main and secondary plugs in Block A.



Note: Chlorite, kaolinite, montmorillonite and illite were added to the natural oil sands to simulate the formulation of oil formations with different clay contents

Figure 1 Primary adsorption curves for ternary systems with different clay contents

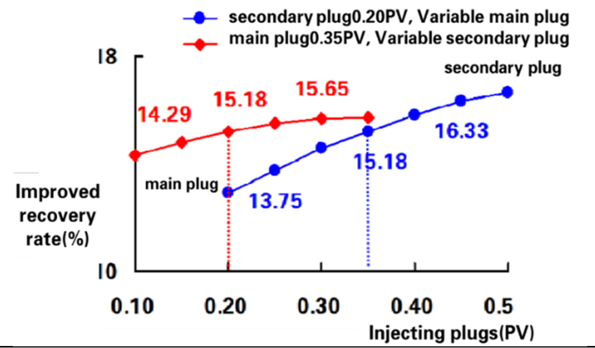


Figure 2 Experimental results of increasing the size of the main segment plug

3. Numerical simulation results

A numerical simulation study was carried out for Block A, oil formation II7-12, and the extension of the main plug could further improve the recovery rate. It has a good technical and economic effect. The results of the numerical simulation study show that the stage recovery can be increased by 0.87% when the length of the secondary plug and the subsequent protection plug remain unchanged and the main plug is extended to 0.43PV; the recovery can be increased by 1.71 percentage points when the main plug and the subsequent protection plug remain unchanged and the secondary plug is extended to 0.35PV.

Table 2 Numerical modelling results for different main plug sizes

Projects	Extending the main plug (PV)			
	0.35	0.38	0.40	0.43
Stage extraction level (%)	16.73	17.10	17.42	17.60
Injected into the pore body at 98% water content (PV)	1.16	1.18	1.20	1.21
Water content at the end of the main plug (%)	84.40	84.83	85.20	85.60
Stage input-output ratio		1:2.08	1:2.33	1:2.13

Table 3 Numerical simulations for different ternary secondary plug sizes

Projects	size of ternary secondary plug				
	0.15PV	0.20PV	0.25 PV	0.30PV	0.35 PV
Stage extraction level (%)	16.73	17.08	17.29	17.49	18.44
Injected into the pore body at 98% water content (PV)	1.16	1.36	1.41	1.46	1.51
Water content at the end of secondary plug (%)	88.1	89.0	89.9	91.1	90.9
Stage input-output ratio		1: 1.58	1: 1.35	1:1.28	1:1.19

In view of the above dynamic situation and problem analysis, in order to further extend the low water content stabilization period, promote further stabilization of unproductive wells and wells with declining water content, control the rebound rate of water content stabilization wells and rebound wells, and improve the recovery rate of the block. The main plug size of Class II lipopeptide compounded with weak base ternary block in block A was extended from 0.35PV to 0.42PV, and the ternary secondary plug size was extended from 0.15PV to 0.35PV. The size of the subsequent polymer-protected plugs remained unchanged. After implementation, the block was injected with 0.86PV, the integrated water content was 90.19% and the degree of recovery was 21.09%, comparing with the numerical simulation prediction, the integrated water content was 1.42% lower, the degree of recovery of the stage was 0.91 % higher and the recovery rate was improved by 16.74%.

Table 4 Block A class II B+ class III oil reservoir weak alkali ternary drive extension plug scheme design table

Stage of plug	Original Solution Design (PV)	Design of Extending Plug (PV)	Actual injected plug size (PV)	Original numerical model prediction		Development Data		
				Integrated water content (%)	Stage extraction level (%)	Integrated water content (%)	Stage extraction degree (%)	Improved recovery (%)
Front plug	0.06	0.06	0.0585	93.33	0.65	93.79	0.91	0.26
Main plug	0.35	0.43	0.4233	85.20	11.89	86.45	12.91	9.13
Secondary plug	0.15	0.35	0.3813	94.60	20.18	90.19	21.09	16.74
Rear plug	0.20	0.20						
Total	0.76	1.04	0.8631					

4. Concluding remarks

Restricted by the evaluation method, the classical plug parameters were previously used for the Class II B+III reservoir. In response to the increased mud content and chemical agent adsorption losses in the Class IIB+III reservoir, the size of the ternary primary and secondary plugs was extended through indoor physical model experiments and numerical simulation studies to ensure better techno-economic results in the development of the ternary composite drive in the Class IIB+III reservoir.

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