Analysis on the Effect of High Concentration Slug before Stopping Polymer Injection

Liqin Zhang
No.5 Oil Production Plant of Daqing Oilfield Company, Daqing, 163315, China
zhliqin@petrochina.com.cn

Keywords: Before Stopping Polymer Flooding, Plugging Slug, Molecular Weight

Abstract: With high concentration or high molecular weight with high concentration plugging slug can enhance recovery further, which make full use of high concentration polymer viscoelastic before stopping polymer flooding. These layers are usually well developed and connected, and has a certain pressure rise space. We optimized two blocks for polymer flooding in this block, the two blocks inject middle molecular weight with high concentration and high molecular weight with high concentration plugging slug respectively, we optimized the molecular weight, and find out that the 25 million plugging slug is better than the 7 million. The study has important guiding significance for late stage of polymer flooding.

1. Introduction

A industrial zone is the first industrial block in our factory, this block exploited horizon is PI3, which covers an area of 6.79 km^2 and geological reserves is 634.38×10^4t, underground pore volume is $1263.11\times10^4m^3$. The well spacing is 150m apart with five-spot pattern, and the total number of Wells was 228, which including 101 injection Wells and 127 production Wells. The average thickness of a single well is 10.57m and the net thickness is 8.27m. The block began polymer flooding in March 2009 and entered the water pick-up period in March 2013, this block water content ascend more than 95% in 2015. The residual oil distributes very dispersedly at the stage, so has little potential for further exploitation [1].

According to the study of numerical simulation, injecting sealing plug before stopping polymer flooding can make the water fall further [2], and the production wells have a secondary effect, we optimized 3 and 4 blocks which wells develop and connect relatively good, the two blocks inject middle molecular weight with high concentration and high molecular weight with high concentration plugging slug respectively. From the experiment, the injection profile got obvious improvement and the water cut falls. By analysis of the effect of different Wells, we optimize the molecular weight, and find out that the 25 million plugging slug is better than the 7 million. It can be used as a reference for subsequent blocks.

2. Parameter Optimization of Mathematical Model

According to the analysis of the block, the plugging slug test before stopping polymer flooding was carried out in 3 and 4 blocks. The 3 fault block covers an area of 1.19 km^2, and geological reserves is 119.13×10^4 t, and the pore volume is $237.40\times10^4m^3$. The number of Wells is 36, which including 19 injection Wells and 17 production Wells. The average thickness of a single well is 10.9m and the net thickness is 9.2m. The 4 fault block covers an area of 1.92 km^2, and geological reserves is 231.93×10^4 t, and the pore volume is $461.17\times10^4m^3$. The number of Wells is 57, which including 26 injection Wells and 31 production Wells. The average thickness of a single well is 13.6m and the net thickness is 11.2m.

According to the study of numerical simulation [3], the molecular weight of block 3 and 4 block carried out optimization. The results shows that 3 block injecting 7 million is better than 25 million, and 4 block injecting 25 million is better than 7 million. So 3 block inject 7 million salt resistant

polymer and 4 block inject 25 million polymer.

Table 1 Comparison of molecular weight optimization of 3 fault block

molecular weight	stopping polymer flooding			water cut 98%	
	water content (%)	stage of oil production (10^4t)	water content (%)	stage of oil production (10^4t)	stage recovery (%)
water drive				2.32	1.97
7 million	93.47	13.03	10.94	18.53	15.56
25 million	93.50	12.84	10.77	18.31	15.37

Table 2 Comparison of molecular weight optimization of 4 fault block

molecular weight	stopping polymer flooding			water cut 98%	
	water content (%)	stage of oil production (10^4t)	water content (%)	stage of oil production (10^4t)	stage recovery (%)
water drive				3.57	1.54
7 million	94.58	26.81	11.56	34.21	14.75
25 million	94.54	26.93	11.61	34.33	14.80

According to the study of numerical simulation, both 3 and 4 flocks have the best effect when they inject the concentration of polymer are 1600mg/L, so the concentration of 1600mg/L is adopted in both zone[4] [5].

Table 3 Comparison of concentration optimization of 3 fault block

concentration (mg/L)	at the end of injection			water cut 98%	
	water content (%)	stage of oil production (10^4t)	stage recovery (%)	Stage of oil production (10^4t)	stage recovery (%)
water drive				2.32	1.97
1200	93.55	12.93	10.85	18.42	15.46
1600	93.47	12.98	10.90	18.52	15.54
2000	93.52	12.96	10.88	18.46	15.49

Table 4 Comparison of concentration optimization of 4 fault block

concentration (mg/L)	at the end of injection			water cut 98%	
	water content (%)	stage of oil production (10^4t)	stage recovery (%)	Stage of oil production (10^4t)	stage recovery (%)
water drive				3.57	1.54
1200	94.57	26.75	11.53	34.12	14.71
1600	94.54	26.93	11.61	34.33	14.80
2000	94.54	26.84	11.57	34.24	14.76

According to the study of numerical simulation [6], high concentration polymer slugs of 0.03PV is injected into both zone 3 and 4.

3. The Implementation of Plugging Slug

Through the analysis of 3 block, with a total of 12 wells can inject 7 million plugging slug. These 12 Wells injected 7 million block slug in April 2015 with injection allocation of 450 m^3 and concentration of 1537 mg/L. It was stopped in May 2015 with 0.029 PV.

Through the analysis of 4 block, with a total of 15 wells can inject 25 million plugging slug. These 15 Wells injected 25 million block slug in May 2015 with injection allocation of 825 m^3 and concentration of 1664 mg/L. It was stopped in july 2015 with 0.03 PV.

Table 5 The single well injection scheme of plugging slug with 7 million

Well No.	fracture pressure (MPa)	net thickness (m)	Before the plugging slug			7 million plugging slug	
			injection pressure (MPa)	injection allocation (m^3)	injection concentration (mg/L)	injection allocation (m^3)	injection concentration (mg/L)
A1	13.9	9.5	12.8	80	1013	70	1800
A2	13.9	5.8	12.9	30	900	30	1300
A3	13.9	7.2	13.0	60	1200	60	1500
A4	14.0	8.2	8.0	40	975	40	1500
A5	14.1	8.8	9.8	60	600	50	1500
A6	13.9	12.2	12.8	20	600	20	1200
A7	14.0	7.8	13.4	25	840	25	1200
A8	14.0	10.1	12.8	20	600	20	1500
A9	14.0	7.3	13.5	35	771	35	1371
A10	13.9	12.4	13.4	30	600	30	1400
A11	14.0	4.5	13.5	20	600	20	1200
A12	14.0	6.8	13.3	60	1000	50	1800
combine	14.0	8.4	12.4	480	869	450	1537

Table 6 The single well injection scheme of plugging slug with 25 million

Well No.	fracture pressure (MPa)	net thickness (m)	Before the adjustment			25 million plugging slug	
			injection pressure (MPa)	injection allocation (m^3)	injection concentration (mg/L)	injection allocation (m^3)	injection concentration (mg/L)
B1	14.0	14.9	11.8	110	1173	60	2000
B2	14.0	13.6	13.5	70	814	60	1800
B3	13.9	17.6	10.2	90	1067	90	2000
B4	14.2	17.2	9.3	40	750	60	1800
B5	13.8	7.1	12.7	35	1457	35	1800
B6	14.0	13.3	12.7	70	1500	70	1971
B7	14.2	11.3	9.4	35	600	40	1500
B8	14.0	5.6	12.9	100	1050	100	1800
B9	14.0	4.1	13.2	30	600	30	1500
B10	13.7	10.5	13.2	40	750	40	1500
B11	13.9	10.0	12.8	20	600	20	1500
B12	14.2	10.9	12.2	40	750	40	1500
B13	14.2	5.2	9.4	115	1487	115	2009
B14	14.0	16.2	12.7	30	500	30	1500
B15	14.0	6.6	13.5	60	600	35	1286
combine	14.0	10.9	12.0	885	913	1024	1664

4. Analysis on the Effect of Plugging Slug

After injecting plugging slug, the injection profile improves dramatically. The fluid entry ratio of poor layer increased by 6.9 percentage points from 53.2% to 60.1% that injected 7 million, and relative suction increased by 7.2 percentage points from 29.3% to 36.5%,at the same time,

the fluid entry ratio of good layer increased by 3.8 percentage points from 74.7% to 78.5%, and relative suction decreased by 7.2 percentage points from 70.7% to 63.5%.

The fluid entry ratio of poor layer increased by 9.8 percentage points from 51.1% to 60.9% that injected 25 million, and relative suction increased by 11.3 percentage points from 27.1% to 38.4%, at the same time fluid entry ratio of good layer increased by 3.9 percentage points from 76.3% to 80.2%, and relative suction decreased by 11.3 percentage points from 72.7% to 61.6%.

The water content was from 95.1% to 93.6%, which decreased 1.5% after injected 25 million plugging slug. Decrease amplitude was 0.7% above the 7 million plugging slug and was higher than

no plugging slug wells beyond 2.2%.

Table 7 Injection profile of plugging slug before and after with plugging slug

Before and after 7 million plugging slug					Before and after 25 million plugging slug			
time	fluid entry ratio of poor layer (%)	fluid entry ratio of good layer (%)	relative suction of poor layer (%)	relative suction of good layer (%)	fluid entry ratio of poor layer (%)	fluid entry ratio of good layer (%)	relative suction of poor layer (%)	relative suction of good layer (%)
Before plugging slug	53.2	74.7	29.3	70.7	51.1	76.3	27.1	72.7
after plugging slug	60.1	78.5	36.5	63.5	60.9	80.2	38.4	61.6

Table 8 Classification of the maximum reduction of water content in plugging slug well area

Classification of the maximum reduction of water content (%)	7 million plugging slug			25 million plugging slug		
	well number	Well number ratio (%)	maximum reduction of water content (%)	well number	Well number ratio (%)	maximum reduction of water content (%)
<1	6	40.0	0.2	4	20.0	0.3
1-3	5	33.3	1.3	5	25.0	1.4
3-5	3	20.0	3.5	7	35.0	3.5
≥5	1	6.7	5.1	4	20.0	6.6
combine	15	100	1.5	20	100.0	3.0

From the reduction of water content of single well, there were 11 wells which maximum reduction of water content exceed 3%.It accounted for 55% of the total number of oil wells, and was 28.3% higher than 7 million plugging slug.

According to the above statistics and analysis, it is believed that the effect of 25 million plugging slug is better than 7 million plugging slug. Therefore, it is recommended to use 25 million molecular weight polymers in the future plugging slug injection.

5. Conclusion

It can enhance recovery further, when inject high molecular weight and middle molecular weight with high concentration before stopping polymer flooding, it make full use of viscoelastic of polymer to displace the oil. The concentration should be higher than 1500mg/L as far as possible within the range of acceptable pressure, these layers are usually well developed and connected, and has a certain pressure rise space.

References

[1] Zhai Yunfnag. Seepage Mechanics [M]. Petroleum Industry Press, 2009(7):13-23.

[2] Chen Taoping, Hu Jingbang. Petroleum Engineering [M]. Petroleum Industry Press, 2000(2): 376-393.

[3] Wang qimin, liao guangzhi, niu jingang. Practice and understanding of polymer flooding technology [J]. Daqing petroleum geology and development, 1999, 18(4):1-5.

[4] Wang xinhai, han dakuang, guo shangping. Polymer flooding mechanism and application [J]. Journal of petroleum science, 1994, 25(1):83-91.

[5] Cheng Jiecheng, Wang Demin. Optimization of molecular weight of polymer for oil displacement [J/OL] Journal of petroleum, 2000, (1).

[6] Yan Yaru Some understanding of polymer flooding test in the secondary reservoirs in the Sazhong Development Zone [J] Daqing Petroleum Geology and exploitation, 2004, 23 (4).