Discussion on the Optimization of Injection and Production Parameters in the Western Fault Zone of T Zone

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Abstract: This article mainly applies the injection-production balance board, combining the dynamic experience of oilfield development to optimize the adjustment method of injection and production parameters in fault area. Based on the law of material balance, considering the pressure limit of the fault plane and the dynamic data of development wells on both sides of the fault, by drawing the pressure balance chart of the injection and production system, the equilibrium formation pressure on both sides of the fault can be calculated. The adjustment direction is given based on the current injection and production status, so as to establish the injection and production parameter adjustment method in the study area.

1 Prediction of balanced formation pressure

1.1 Calculation of injection volume

For a water injection development block, the formula for calculating the daily liquid injection volume is shown in Equation 1-1:

$$Q_i = I \times (P_i - P) \times N_w \quad (1-1)$$

in the formula: Q_i —— Daily injection volume, m³/d;

I —— Water absorption index, m³/ (MPa×d);

P_i —— Bottom flow pressure of injection well, MPa;

P —— Formation pressure, MPa;

N_w —— Number of wells.

Water absorption index I means daily injection volume of water injection wells under unit water injection pressure difference (m³/ (MPa×d)). [1] It reflects the water injection capacity of the injection well and the water absorption capacity of the reservoir. At the same time, it can be used to analyze the working conditions of water injection wells and the change of water absorption capacity of the reservoir. The formula for calculating the water absorption index is shown in Equation 1-2.

$$I = Q_{wi} / (P_i - P) \quad (1-2)$$

in the formula: I —— Water absorption index, m³/ (MPa×d);

Q_{wi} —— Daily well injection volume, m³/d;

P_i —— Bottom flow pressure of injection well, MPa;

P —— Formation pressure, MPa;

The bottomhole flow pressure, formation pressure, and a number of wells in the injection volume calculation formula can be obtained from the oilfield production dynamic data. Therefore, the amount of liquid injection in a certain block can be calculated.

1.2 Calculation of liquid recovery

For a water injection development block, the formula for calculating the daily liquid volume is shown in Equation 1-3:

$$Q_l = B \times B_l \times \alpha \times J \times (P - P_{wf}) \times N_o \quad (1-3)$$

in the formula: Q_l —— Daily fluid volume, m³/d;

B —— Injection-production ratio, Dimensionless;

B_l —— Crude volume factor, constant 1.35;

α —— Dimensionless fluid collection index, Dimensionless;

J —— Initial liquid collection index, m³/ (MPa×d);

P —— Formation pressure, MPa;

P_{wf} —— Bottomhole flow pressure, MPa;

N_o —— a Number of oil wells.

The bottom hole flow pressure and the number of oil wells in the calculation formula of the liquid production volume can be obtained from the production dynamic data. Therefore, the amount of liquid collected in a certain block can be calculated.

1.3 Calculation of balanced formation pressure

A reasonable injection production system can not only meet the effect of increasing oil production, but also meet the formation pressure to maintain balance [2]. That is to say, under a reasonable injection-production ration, a reasonable ratio between the injection volume and the volume of the produced liquid is satisfied. There is a balance relationship between the volume of liquid and the volume of liquid injected into an injection production system:

$$Q_l = Q_i \quad (1-4)$$

$$B \times B_l \times \alpha \times J \times (P - P_{wf}) \times N_o = I \times (P_i - P) \times N_w \quad (1-5)$$

The simplified calculation of the equilibrium formation pressure is shown in Equation 1-11:

$$P = \frac{I \times P_l \times N_w + B \times B_l \times \partial_o \times J \times P_{wf} \times N_o}{B \times B_l \times \partial_o \times J \times N_o + I \times N_w} \quad (1-6)$$

Each parameter in Equation 1-6 is explained in the calculation of the injection volume and the liquid recovery volume. From this, the equilibrium formation pressure can be calculated.

2 Optimization of injection and production parameters

By comparing the equilibrium pressure calculated based on the injection-production balance relationship with the original formation pressure, there are three cases:

Equilibrium formation pressure is higher than original formation pressure.

For this pressure state, the energy of the water injection well stays in the formation, which leads to an increase in formation pressure, which is prone to safety problems such as casing damage. In this case, according to the pressure balance diagram of the injection and production system, under the premise of maintaining the bottom flow pressure of the production well, people should reduce the injection pressure of the injection well and reduce the amount of liquid injection in the block. The equilibrium formation pressure fell back within the safe range of the original formation pressure.

2.1 Equilibrium formation pressure equals original formation pressure

For this pressure state, it can ensure that the injection and release of underground energy is in a balanced state, and the formation pressure is maintained at the original formation pressure level. At this time, the existing

injection and production parameters can be maintained in the block for production.

2.2 Equilibrium formation pressure is lower than original formation pressure

For this pressure state, the energy supplemented by the water injection well is insufficient to meet the formation energy requirements in the production process. Formation energy is in deficit. In order to maintain a certain production pressure differential, formation energy needs to be supplemented. According to the pressure balance diagram of the injection-production system, on the premise of keeping the bottom flow pressure of the production well constant, people should increase the injection pressure of the injection well and increase the amount of fluid injection in the block, so that the lower equilibrium formation pressure can be returned to the original formation pressure Within the scope of safety.

3 Applications

Four faults were selected in the T zone fault area, and the injection-production balance of fault blocks on both sides of the fault was analyzed (Table 1). The results show that the equilibrium formation pressure of the F1-E, F1-W, F2-c2-E and F3-x12-N fault blocks is close to the original formation pressure. It can maintain existing injection and production schemes. The equilibrium formations of F2-c2-W, F3-x12-N, F3-S and F3-N fault blocks are slightly larger than the original formation pressure. It is necessary to appropriately reduce the injection pressure of the injection well and the injection volume to reduce the equilibrium formation pressure.

Table 1 Optimization and adjustment scheme of well pattern injection and production parameters on both sides of the fault in the T zone fault area

fracture	Fault block	Balance formation pressure /Mpa	Original formation pressure /Mpa	Fault pressure limit /Mpa		Optimization of injection and production parameters			
				range	average	Current well pressure (MPa)	Today's injection volume (m3/d)	Adjusted bottomhole flow pressure of water well (MPa)	Adjusted daily injection volume (m3/d)
F1	F1-E	9.97	10.04	1.9~4.1	3	19.69	69.66	Maintain the status	
	F1-W	10.56	10.03			21.05	109.33	Maintain the status	
F2-c2	F2-c2-W	11.2	10.0	3.6~6.0	4.8	21.12	75	18.6	52.7
	F2-c2-E	10.56	10.03			21.05	109.33	Maintain the status	
F3-x12	F3-x12-S	11.15	10.1	0.73~2.3	1.52	21.56	54.33	18.3	29.7
	F3-x12-N	9.62	9.92			20.47	90	Maintain the status	
F3	F3-S	14.92	11.56	10.25~16.5	13.37	19.6	275.42	14.7	152.94
	F3-N	13.99	11.21			22.51	149.27	18.0	54.1

4 Adjustment measures and effect evaluation of fault area

Based on the research results of remaining oil distribution and fault pressure limit in the T zone fault area, the injection and production parameters in the T zone fault area were optimized and adjusted.

4.1 Water injection well workload

4.1.1 Adjustment of water injection well scheme

The number of wells implemented was 73. The number of interval adjustments is 122. The number of increased intervals is 11, and the daily water injection increase is 218m³. Among them, 19 wells were adjusted for the interlayer, which increased the number of intervals by 11 and the daily water injection volume increased by 134m³; The number of horizontal adjustment wells is 26, and the daily water injection is reduced by 93m³; the number of wells for low-pressure wells and measure wells is 23, and the daily water injection is increased by 284m³; The number of wells containing water rise was controlled by 5 wells, and the daily water injection was reduced by 107m³. After the implementation of the plan, 164 wells with no measures were effective, with a daily increase of 100.1t and a daily increase of 25.6t. The comprehensive water cut decreased by 0.25 percentage point and the flow pressure increased by 0.13MPa.

4.1.2 Improve injection-production relationship

The number of water injection wells for filling holes was 2 wells, and the daily water injection increased by 88 m³. The number of wells over repaired for water injection wells was 14 and the daily water injection recovery was 1367 m³.

4.1.3 Water injection well injection measures

The number of fracturing wells with water injection wells is 10, with a daily increase of 516 m³; the number of water injection wells with acidification wells is 48, with a daily increase of 1069 m³.

4.1.4 Periodic water injection

The number of periodic water injection wells is 26, and the daily water injection is reduced by 2004 m³.

4.2 Production wells measures

According to the distribution law of remaining oil in the fault area, the measures are optimized to tap the potential of the remaining oil.

According to the type of sandstone with low water content, the remaining oil types on the river side and the degraded parts, ordinary fracturing was adopted and 4 wells were implemented[3]; For the remaining oil types

of continuously developed thin reservoirs with relatively low water cuts and production levels, multi-fracture fracturing treatment was adopted to implement 13 wells; For the remaining oil types at the top of thick oil layers, selective fracturing was adopted to implement 3 wells. A total of 20 wells were implemented for oil well fracturing. After initial fracturing, the daily fluid increase was 790t, and the daily oil increase was 167t. The comprehensive water cut decreased by 8.23 percentage points, and the average daily oil increase per well was 8.3t. This is 1.6 times the fracturing effect in the whole area, and the cumulative oil increase is $2.9029 \times 104t$.

In order to improve the relationship between injection and production, 10 wells were replenished. At the initial stage after hole filling, the daily fluid increase was 224t, and the daily oil increase was 39t, the comprehensive water content decreased by 4.64 percentage points, and the cumulative oil increase was $0.4894 \times 104t$.

4.3 Parameter adjustment of production well

For the wells cannot be tapped to measure potential but have residual oil potential, people should take measures to increase production pressure differentials and increase production efficiency to tap potential. A total of 77 oil production wells were parameterized, with a daily increase of 247t and a daily increase of 32t.

Overall effect

By optimizing the injection and production parameters in the North T zone fault area, the pressure difference on both sides of each fault is within a reasonable pressure limit. The pressure difference on both sides of the Saar Formation fault decreased by 1.0 MPa. The pressure difference between the grapevine and Gaotaizi faults decreased by 0.42 MPa. The pressure differential across the fault is transitioning to equilibrium. F2-c2, F3-X22, and F3 balance the pressure difference between the balanced formations on both sides of the three faults. F1 fault side balance formation pressure difference remains unchanged. The daily average oil production of a single well in the fault zone is 2.67t, and the comprehensive water content is 89.76%. Compared with that before adjustment, the average daily oil production of a single well is increased by 0.26t, and the comprehensive water content is decreased by 0.86 percentage points.

5 Conclusion

5.1 According to the pressure balance plate of the injection production system, the equilibrium formation pressure on both sides of the fault is calculated. Combined with the current status of injection and production, it can guide the adjustment of injection and production parameters.

5.2 After applying the research results to optimize the injection and production parameters in the fault area, the pressure difference across the fault transitioned to an equilibrium; oil production increased; comprehensive water cut decreased; and the development effect improved significantly.

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