Determination of reasonable test time of periodic injection well in Punan Oilfield

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Abstract: There were 232 stratified injection Wells in Bunan Oilfield in 2020, including 69 year-round injection Wells and 163 periodic injection Wells. There are many periodic injection Wells and the pressure recovery is slow after injection. After the test, the pressure fluctuates greatly, and the data cannot be reported outside in time, which affects the water distribution. In 2020, according to our actual statistics, the water injection pressure of 38 Wells had a difference of more than 2MPa from the qualified pressure point of the test data before the test of stratified injection well. The reason of pressure discrepancy is mainly related to periodic water injection. In view of this situation, we conducted an investigation on the cycle injection Wells of the whole mine in 2020. The pressure recovery curve was plotted according to the daily injection volume and the length of periodic injection stop time. At the same time, the method of determining the reasonable testing time of periodic injection well is put forward, which provides scientific basis for determining the testing time of periodic injection well.

Key words: Cycle water injection; pressure recovery; reasonable test time.

1. Pressure recovery of periodic water injection well after water injection

There are three reasons for periodic water injection in punan oilfield. One is to take periodic water injection directly at the initial stage of transfer; Second, intermittent water injection can supplement energy in order to control the water cut rising rate of oil Wells. Third, because the water absorption can not pass the winter, the winter cycle stop injection. Therefore, we made statistics on the recovery of water injection pressure in 38 Wells after water injection was resumed (see Table 1).

Table 1. Recovery statistics of periodic injection well pressure in Punan Oilfield

Well	Injection allocation (m^3)	Stop injection cycle (m)	Pressure recovery days (d)	Well	Injection allocation (m^3)	Stop injection cycle (m)	Pressure recovery days (d)
7P2 64-86	30	3	31	7P2 14-98	50	2	38
7P2 74-80	30	3	30	7P1 72-130	50	2	35
7P1 86-138	30	1	15	7P2 36-88	40	3	38
7P2 78-78	20	2	40	7P1 78-44	55	3	45
7P1 64-66	30	3	50	7P1 94-12	50	3	48
7P2 30-96	20	5	35	7P1 80-28	40	2	40
7P1 72-20	20	5	36	7P1 68-14	40	3	25
7P1 78-28	30	5	38	7P1 43	40	3	35
7P2 26-90	30	5	36	7P1 74-134	50	2	25
7P2 68-78	20	5	38	7P2 62-80	40	2	40
7P2 40-92	30	4	30	7P1 60-36	40	2	35
7P2 74-63	25	2	30	7P1 92-140	55	2	35
7P2 94-76	30	3	25	7P2 48-78	60	1	35
7P2 44-90	25	2	40	7P1 70-24	60	2	40
7P2 78-63	20	2	27	7P1 64-28	65	3	55
7P1 66-16	35	3	38	7P2 78-74	65	2	45
7P1 70-52	50	5	48	7P1 48-50	75	2	60

7P180-56	30	3	36	7P220-98	70	2	60
7P214-100	50	2	35	7P202-86	75	2	45

The time required for pressure to return to normal for different types of Wells was calculated based on different injection allocation and shutdown cycles (see Table 2).

Table 2. Summary of pressure recovery of periodic injection Wells after water injection

Daily water injection	Stop injection cycle (m)	Pressure recovery days (d)
<30 m^3	≤3 months	24
	5 months	33
30 m^3～60 m^3	≤3 months	36
	5 months	45
>60 m^3	≤3 months	50

According to the data in the table, if the daily injection is less than 30m3 and the injection stop period is less than 3 months, the average days of single well pressure recovery is 24 days; if the injection stop period is 5 months, the average days of single well pressure recovery is 33 days.
With daily injection of 30m3 to 60m3 and injection stop period <3 months, the average days of single well pressure recovery was 36 days, and the average days of single well pressure recovery was 45 days for Wells with injection stop period of 5 months.
The daily injection allocation was greater than 60m3, the injection stop period was less than 3 months, and the average single well pressure recovered stable days was 50 days. The data in Table 2 can be used to make curves of the average pressure recovery days of Wells with different injection volumes and stoppage periods (see Figure 1). It can be seen that the longer the stoppage time, the longer the pressure recovery time.

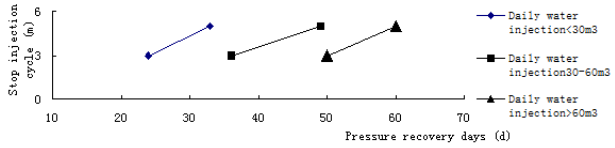

Figure 1. Curve of average well pressure recovery days with different daily injection rates and shut-down periods

2. Determination of reasonable test time of periodic injection well

2.1 Determine a reasonable test time on the pressure recovery curve

According to the above investigation, we drew a single well pressure recovery curve for Wells with different daily injection volume and injection shutdown period, and determined a reasonable test time through the pressure recovery curve.
For example, well 7P166-16, with daily injection of 35 m3, will be shut down in August and September 2020. In fact, the well was washed and transferred to injection on September 27. The initial injection pressure was 4.7mpa, and the pressure gradually recovered with the extension of injection time. The pressure recovered to 7.5MPa and stabilized on October 25. The pressure recovery time was 30 days. The stratification test was carried out on November 1st and finished on November 3rd. The qualified pressure point is 7.7mpa (see Figure 2). Water injection was basically stable under this pressure when tested in the first half of 2003.

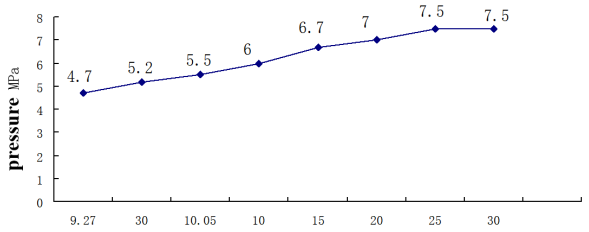

Figure 2. 7P166-16 Water injection pressure recovery curve

The injection was 35 m3 per day, the injection stop period was 2 months, and the pressure recovered and stabilized for 30 days.

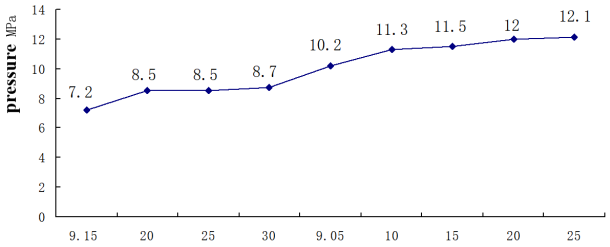

Figure 3. 7P172-130 Water injection pressure recovery

The injection was 50m3 per day, the injection stop period was 2 months, and the pressure recovered steadily for 35 days

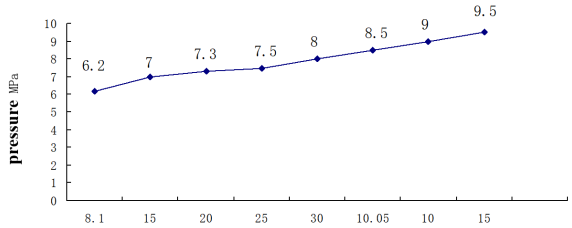

Figure 4 7P143 Water injection pressure recovery

The injection was 40m3 per day, the injection was stopped for 3 months, and the pressure recovered steadily for 35 days

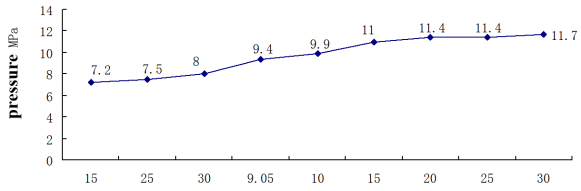

Figure 5. 7P278-74 Water injection pressure recovery

The injection was 65m3 per day, the injection was stopped for 2 months, and the pressure recovered steadily for 45 days

2.2 Determine the reasonable test time with the meter algorithm

It can be seen from the above Wells with different injection volume and stop-injection cycle that there is a good linear relationship between the recovery time of injection well pressure and injection volume and stop-injection cycle. The longer the injection stoppage period, the longer the recovery time of injection pressure; The larger the injection amount is, the longer the recovery time of water injection pressure is. In the same stop-injection period, the longer the recovery time of injection pressure is for Wells with large injection volume. The quantitative relationship of reasonable test time of periodic injection well can be obtained by analyzing and processing the regular data in the production process by using multiple regression method.

It is analyzed and processed by multiple regression, and its normal equation is:

$$\begin{aligned} L_{11}b_1+L_{12}b_2+\ldots\ldots+L_{1m}b_m&=L_{10}\\ L_{21}b_1+L_{22}b_2+\ldots\ldots+L_{2m}b_m&=L_{20}\\ L_{m1}b_1+L_{m2}b_2+\ldots\ldots+L_{mm}b_m&=L_{m0} \end{aligned} \quad (1)$$

$$b_0=\overline{Y}-b_1\overline{X}_1-\ldots\ldots-b_m\overline{X}_m \quad (2)$$

The regression equation is $Y=b_0+b_1X_1+b_2X_2+b_mX_m$ (3)

L_{ij}--- The value to be calculated can be obtained by the method of extremum of multivariate function.

Bi -- regression coefficient, obtained from equations (1);

B0 -- the constant term in the sum of regression squares is obtained from Equation (2);

-- Mean value of observed value of dependent variable;

I -- Mean value of observed value of independent variable;

Xi-- Statistical variables.

Through the statistical arrangement of relevant data, the coefficients of B1 and B2, L10 and L20, were respectively solved by using the method of extremum of multivariate function (the calculation data was omitted), and the following binary linear equations were obtained:

$$\begin{aligned} 2672.5b_1+240b_2&=2181.5 \quad (4)\\ 240b_1+3960b_2&=906 \end{aligned}$$

Solving equations: B1 =0.70005 B2 =-0.1803 B0 = 14.2600

When b0, B1 and B2 are substituted into Equation (3) and relevant parameters are substituted for Y, X1, X2 and X3, the following regression equation can be obtained:

$$Th = 14.2600 + 0.70005\ Pz\ 0.1803\ St \quad (5)$$

Where Th --, days for water injection pressure to recover and stabilize, d;

Pz -- Daily injection distribution of water injection well, t;

St - Injection stop period, d.

Equation (5) is the mathematical model of quantitative calculation of the time of periodic injection well pressure recovery and stability, i.e. reasonable test time.

2.3 Comparison of the two methods

In order to verify the error between the calculation method and the curve method (determining the reasonable test time on the curve) in determining the reasonable test time, we selected 12 Wells and used the two methods to determine the reasonable test time respectively. The comparison results are shown in Table 3.

Table 3 Calculation method and curve method to determine the reasonable test time comparison table

WELL	In 2020 Stop injection cycle (m)	Injection allocation (m^3)	Calculation of pressure Restore the number of days	The actual pressure Restore the number of days	poor
7P164-34	2	60	45	40	-5
7P170-16	2	30	25	27	2
7P172-130	1	50	43	40	-3
7P174-132	3	70	47	43	-4
7P182-128	2	40	31	35	4
7P224-92	4	50	27	30	3
7P230-90	2	60	45	43	-2
7P206-90	3	60	40	41	1
7P174-66	2	40	31	34	3
7P166-80	4	35	17	20	3
7P214	2	55	41	39	-2

It can be seen from the table that compared with the curve method, the error of single well is within 5 days, which is basically consistent with the actual situation and can be used to guide production.

3. Conclusion

3.1 after the application of this method to determining cycle injection Wells open hole pressure stable, without special funds input, the method is simple and easy, simply enter stop water injection cycle and injected water volume of data, to calculate the pressure after the well open well stability returns the number of days, when the actual validation, error in about five days, can be used to guide cycle injection well test of time.

3.2 With the extension of well opening time, the pressure of periodic injection water well gradually increases. After a period of time, the pressure gradually recovers and stabilizes at this pressure point, which is the best time for testing.

3.3 For the same well, the pressure recovery time is different at different time periods or with different injection amounts. It is not fixed, but dynamic and constantly changing. According to the pressure recovery time of periodic injection well after well opening, selecting appropriate test time is an effective way to reduce retesting Wells and ensure the normal water distribution of injection well.

3.4 The pressure recovery law of under-injection Wells is inconsistent with the above formula. All the Wells involved in calculation can complete injection allocation, even if injection allocation is consistent with actual injection.

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