Influencing factors and strategies of water drive oilfield development effect

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Abstract: At the present stage, with the rapid social and economic development, people's demand for oil resources continues to rise. Based on this situation, oil prices continue to rise. At the same time, the management of old oil fields is difficult. In this regard, combined with the example of S oilfield, this paper analyzes the factors affecting the production of S water drive oilfield, and puts forward the adjustment strategy of the production plan, hoping to provide reference for related units.

Keywords: Water drive oilfield; Development effect.

1. Introduction

Petroleum gas resources are important resources to ensure the stable development of society and have key economic strategic value to a certain extent. When developing oil fields, water flooding mode is generally adopted. The final production effect is very obvious, and sufficient technology and production tools can be obtained. However, there are still some problems in water flooding mining activities, so it is of great significance to actively carry out relevant influencing factors, and at the same time, scientific strategies are of great significance to improve the oilfield exploitation effect [1].

2. Development status of S oilfield

The oil area of S oilfield has been proved to be 23.1K ㎡, and the geological reserves have been proved to be 700.00*104t. The exploration and development began in 20008. In September 2020, 73 Wells were opened in S oilfield, with 206.62m³/d of liquid production and 135.64m³ of oil production. There were 16 Wells, with 23.05m³/d of water injection per well and an injection-production ratio of about 1.35. At present, the total oil production volume reaches 22.59*64m³, with 34.5% water cut.

3. Analysis of influencing factors of S water drive oilfield production

3.1 The law of diminishing

At present, Arps model is widely used in China, which is a typical mathematical model in the study of yield decline law, mainly covering hyperbolic decline, harmonic decline and exponential decline models, as shown in the following formula:

$$\frac{Q}{Q_i} = \left(\frac{D}{D_i}\right)^n \quad (1)$$

Where, Q represents the oil production at t time in the diminishing process, unit 104m³/a, 104m³/mon, m³/d. Represents instantaneous decline rate, unita-1, cmon-1, d-1. Q_i Represents the oil production at the early stage of decline period, unit 104m³/a, 104m³/mon, m³/d. D_i Represents the initial decline rate after the onset of decline, unit a-1, cmon-1, d-1. N Exponent of decline. The dynamic production information is analyzed, and the monthly output of the oilfield is obtained according to the method of decline law. See the table below.

Table 1 Monthly oil production of S oilfield

Time	2008.01	2010.10	2013.11	2016.11	2018.05	2020.11
Oil production	0	1200m³/mon	2900 m³/mon	5900 m³/mon	4100 m³/mon	4000 m³/mon

By means of analysis, the decline type of S oilfield belongs to hyperbolic decline type, Where n is 0.65, And the initial decline rate of S oilfield is 23.74%, as shown in the following formula:

$$Q = \frac{Q_i}{(1+0.048t)^{1538}} \quad (2)$$

The output data can be predicted with the help of the above equation.

3.2 The recoverable reserves are calculated by decreasing curve

Based on the dynamic analysis information of S oilfield, the production decline calculation formula is obtained. With the help of the above formula, the recoverable reserves are calculated as 56.24*104m ³, and then the recoverable reserves of S oilfield are 48.83*104m ³, and the recovery factor of S oilfield is 22.47%.

3.3 Factors affecting yield change

(1) Reservoir heterogeneity. The reservoir of S oilfield has strong heterogeneity, and the longitudinal permeability range reaches 104.56. On the plane, the sand body is unconnected, which makes the water injection ineffective and the effective rate is low.
(2) Formation pressure. The formation energy of S oilfield declines rapidly and its distribution is not balanced. The original formation pressure of S oilfield is 17.89. However, due to the lack of water injection in the later production, more attention is paid to natural energy in the production activities, resulting in the rapid decrease of formation pressure and serious contradiction between injection-production layers in the reservoir [2].
(3) Injection-production pattern. In some areas, there is no scientific injection and production well pattern, and mining is carried out without water injection, which makes the formation energy deficit more serious. Some mining Wells are located in the lithological pinch-out zone and the edge of sand body, and the effect cannot be fully guaranteed after water injection.

4. S oilfield development plan adjustment strategy

4.1 Forecast the effect of production plan development at present stage

In order to make effective adjustment in the later stage, it is necessary to reasonably predict the current development plan, and then provide reasonable adjustment strategy for the next plan. Using the numerical simulation method to predict the development plan, the development dynamic design is as follows: The simulation time is until 2026, according to the annual water volume, the injection amount is fixed, the end value of injection pressure is within 35Mpa, and the development dynamic of S oilfield is predicted. By 2026, according to the current development plan, the water content of S oilfield is about 75%, the oil output is 42m³/d, and the recovery degree is expected to be 22%.
In addition, through the study of oil saturation distribution map of S oilfield, it can be found that water injection in some areas of S oilfield cannot be swept, and is distributed in disconnected sand body areas. Meanwhile, in areas with poor physical properties, remaining oil is widely distributed in L2 reservoir, which is an area with ineffective water injection or imperfect perforation, which is a favorable area for tapping potential [3].
From the perspective of stratified pressure distribution, the reservoir pressure distribution has significant heterogeneity, which reflects that the existing water injection methods and well pattern water flooding control range is small. The l2 low-pressure block covers the following parts:
G41-19 east-west low pressure zone; (2) The north-south low pressure from H29-11 to G4326. H33-15 and G42 injection Wells are mainly distributed in high-pressure areas, mainly because of the difference in injection-production ratio among different well groups. See below.

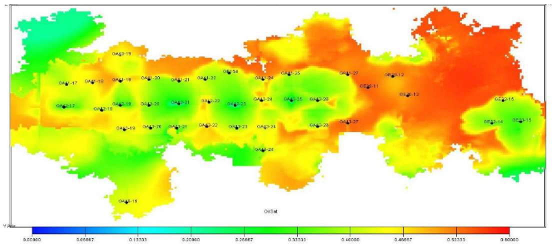

Fig. 1 The distribution of l2 layer oil saturation under the condition of 75% comprehensive water cut of existing well pattern S oilfield

With the help of numerical simulation method, the recovery rate of the current production plan of S oilfield is only 22%, which reflects the shortcomings of the production plan.

4.2 Optimization of injection well pattern by filling holes

In view of the lack of perfection of injection-production and the interlayer contradiction of injection-production well pattern in S oilfield, the stratification information of reservoir strata was studied in depth. According to the existing injection-production scheme and perforation, the well layers with good filling potential were fully optimized, and the effect was predicted by numerical simulation method.
Due to the effective improvement of the production fluid level of the filling well, the fluid increase of the filling well is 1.5m³/d, and the oil increase of S oilfield is 23.6m³/d, the development effect is predicted by using the numerical simulation method, and the optimization scheme of the filling hole is formulated scientifically based on this. The simulation time is until 2026, and the comprehensive water cut of S oilfield in this period is about 75%. The recovery degree is 23%, 1% higher than the existing recovery degree.
When the comprehensive water cut is about 75%, the hole filling strategy can effectively improve the flooding range. Filling hole injection well pattern in the eastern part of Long L2 layer can effectively control the area with high oil saturation. See below.

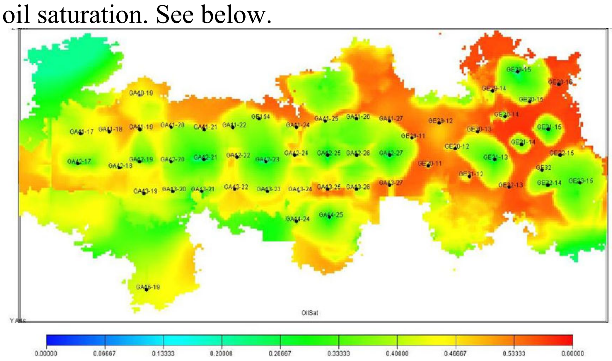

Fig. 2 Distribution of l2 layer oil saturation under the condition that the comprehensive water cut of S oilfield is 75% under the prediction of filling hole strategy

4.3 Predict the effectiveness of well measures

As for the Wells in S oilfield that have been put into development, the production time of 50% Wells is about one year, so the liquid production capacity has decreased. The current production level is only 40% of the initial level. In addition, some Wells cannot be injected with water. The main reasons are as follows :(1) the injection water has the phenomenon of large orifice protruding or pointing. (2) The lack of sufficient formation energy affects the liquid supply capacity. (3) The water cut increases rapidly, affecting the yield [4].

With the help of numerical simulation method, it is predicted that by 2026, the recovery degree of S oilfield will increase by 1.3%, and the liquid production capacity of single well will increase to 5m³/d. In order to fully improve the recovery factor of S oilfield and adjust the recovery strategy, the main method is to optimize the reservoir by filling holes, and effectively improve the recovery degree of S oilfield with different adjustment strategies by means of fracturing and other reservoir reconstruction methods. By 2026, the S field is expected to increase ultimate recovery by 2.3% through a combination of retrofit and hole filling.

4.4 Prediction of effect of crystal injection and pore pressure production strategy

(1)Well test results in S field. In 2020, two Wells and four oil Wells will be tested for pressure recovery, as shown in the table below.

Table 2 Analysis of well test results of S oilfield in 2020

The well type	The well				Wells	
No.	H29-14	H30-11	H30-16	H-13	H29-15	G42-21
Bottom hole flowing pressure	8.281 MPa	6.630 MPa	1.801 MPa	2.639 MPa	27.794MPa	36.161MPa
Interpretive formation pressure	21.201MPa	24.069MPa	17.681MPa	12.271MPa	25.228MPa	30.425MPa
Production and water injection pressure difference	12.920MPa	17.439MPa	15.880MPa	9.632 MPa	2.566 MPa	5.736 MPa

It can be seen from the above table that the formation pressure presents an uneven distribution state, which is not significantly different from the numerical simulation. In this case, there is a significant difference in production pressure. The maximum and minimum production pressure difference are 17.44mpa and 1.4mpa respectively. H29-15 interprets the formation pressure as 25.23mpa, and compared with H30-16 and H29-14, the extrapolated formation pressure difference is within the range of 4-7.5mpa, reflecting that the pressure wave and radius of injection-production Wells are not connected, and the difference increases with the increasing distance [5].

Determine flow pressure reasonably. ① Pump mouth pressure and reasonable pump efficiency are:

$$\mathrm{N} = \frac{1}{\left\{\frac{\mathrm{Fgo-a}}{10.197\mathrm{P_p}}+\mathrm{B_t}\right\}\times(1-\mathrm{fw})+\mathrm{fw}} \quad (3)$$

Among them， a is the dissolution coefficient of natural gas， unit m³/Mpa. Fw is integrated water cut，For the decimal. P_p is the pump pressure， unit Mpa. F_{go} is gasoline than， unit m³/t. B_t Is based on the pump pressure crude oil volume coefficient. N Represents pump efficiency.

② The minimum relationship between pump inlet pressure and flow pressure is:

$$P_{wf} = P_p + \frac{H_m - H_p}{100} \times [\rho_0 \times (1 - fw) + \rho_w \times fw] \times F_x \quad (4)$$

Among them，H_p is the depth of the pump，unit m. F_x is the average correction coefficient of liquid density. ρ_0 is the average crude oil density above the pump pressure and below the moving liquid surface, g/cm³. H_m is the depth in the middle of the reservoir， unit m. P_{wf} is the minimum reasonable flow pressure，unit Mpa.

Moisture content and minimum flow pressure are generally solved according to the relationship between minimum flow pressure and pump pressure. By the above formula，To obtain P_{wf} is 5.1Mpa，Close to the mean bottom hole pressure of some production Wells in well test statistics(4.78MPa).

(3) Determine a reasonable differential pressure. After the reasonable bottom hole flow pressure and formation pressure are determined, the reasonable value of production pressure difference can be calculated:

$$\Delta P = P_i - P_{wf} \quad (5)$$

The reasonable bottom hole flow pressure is 5.1Mpa，So the reasonable production differential pressure is 12Mpa.

5. Conclusion

To sum up, in order to fully ensure the stable development of petroleum enterprises and provide enough oil resources for daily life and production, relevant departments should pay attention to downhole workover work to improve the production effect of oil fields. As for the exploitation effect of S oilfield, this paper analyzes the factors influencing the exploitation with the help of Arps model. In view of the insufficiency of reservoir heterogeneity and formation pressure, the final recovery factor can be increased by 2.3% through measures of reconstruction and hole filling, effectively improving the exploitation effect.

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