Research on Calculation Method of Rational Allocation of Injection Well Intervals

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Abstract: After water flooding reservoir has been carried out for a certain period of time, the contradiction between plane and vertical becomes increasingly prominent, rational allocation of water injection is becoming more and more important. The dynamic balance of water injection and oil recovery system is analyzed and combined with dynamic and static data. It is suggested that the split coefficient method be used instead of the traditional KH or H method, calculation of rational injection water volume for injection, strive to achieve precise water distribution.

Introduction

Due to heterogeneity of reservoir, when the development of water injection reaches a certain period of time, there will inevitably be a decline in oil production and a significant decrease in formation pressure. At this time, the rational allocation of injection is very important. At present, KH method or H method are widely used to separate water injection, These two methods consider the factors relatively single, and can not fully reflect the actual conditions of the underground. Therefore, on the basis of analyzing the dynamic balance of water injection system and oil production system, a method of calculating the reasonable water injection rate of water injection wells by using split coefficient method is proposed. The splitting coefficient includes plane splitting and longitudinal splitting between injection wells and connected wells, plane splitting coefficient between injection well and production well. It can be calculated according to the position of pressure wave between oil and water wells, the longitudinal splitting can be dynamically split according to the water absorption indicating curves at each level.

Determination of Plane Splitting Coefficient

Determination of Pressure Balance Position between Oil and Water. There is a balance between water injection well and production well. Assuming homogeneous reservoir The distance between the oil well and the injection well is d (m),Water production by Qw (m^3/d),respectively, Qi (m^3/d) water injection for stable production, oil well and Water injection well Between Formation permeability is[1]:

$$K=\frac{\mu B}{1.842\times10^{-3}(P_{wi}-P_{wf})}\left[\frac{Q_i}{K_{rw}(1)h_1}+\frac{Q_w}{K_{rw}(f_w)h_2}\right]\ln\frac{d}{r_w} \quad (1)$$

In the formula:

μ—Viscosity of crude oil, MPa.s;

B—volumetric coefficient of crude oil, f;

P_{wi}—bottom hole flow pressure of injection well, MPa;

P_{wf}—well bottom pressure, MPa;

h_1—Effective thickness of injection well formation, m;

h_2—effective thickness of oil well formation, m;

r_W—well radius, M.

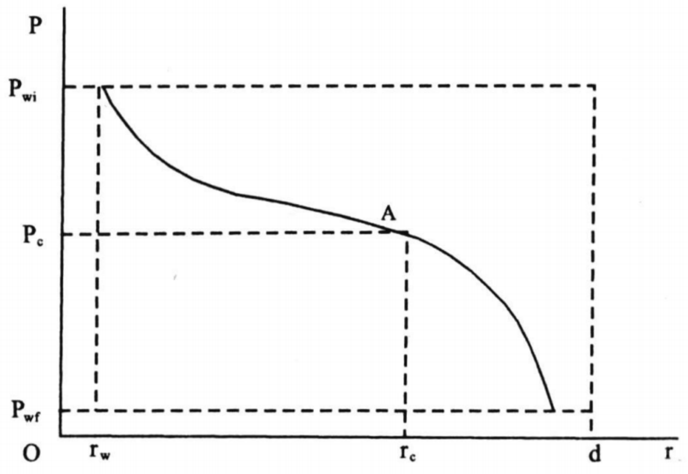

Fig. 1 Distribution of formation pressure between oil and water wells

The pressure expression of the pressure distribution curve between the oil well and the water well is expressed as follows:

$$P = P^{wf} - \frac{\mu B}{1.842\times10^{-3}K}\left[\frac{Q_i}{K_{rw}(1)h_1}\ln\frac{r}{r_w} - \frac{Q_w}{K_{rw}(f_w)h_2}\ln\frac{d-r}{d}\right] \quad (2)$$

The position of the inflection point represented by (2) is the pressure position at the edge of the oil well [2], therefore, we can get the two derivative of the upper form and collate it, then we get the distance from the edge to the well:

$$r_e = \frac{d}{1+\sqrt{\frac{Q_w K_{rw}(1)h_1}{Q_i K_{rw}(f_w)h_2}}} \quad (3)$$

In the formula:;

K_{rw} (1)—Relative permeability of formation water when water yield is equal to 1;

K_{rw} (fw)—Relative permeability of formation water under any water production rate, the following methods determine.

According to Darcy's law and the definition of moisture content, we can get it:

$$f_w = \frac{q_w}{q_w+q_o} = \frac{1}{1+\frac{\mu_w K_{ro}}{\mu_o K_{rw}}} \quad (4)$$

The ratio of oil-water relative permeability to water saturation satisfies the following formula:

$$\frac{K_{ro}}{K_{rw}} = Ce^{-aS_w} \quad (5)$$

Replace (5) with (4):

$$f_w = \frac{q_w}{q_w+q_o} = \frac{1}{1+\frac{\mu_w}{\mu_o}Ce^{-aS_w}} \quad (6)$$

The solution to Sw is:

$$S_w = -\frac{1}{a}\left[\ln\left(\frac{\mu_o}{C\mu_w}\right) + \ln\frac{1-f_w}{f_w}\right] \quad (7)$$

First, the relative permeability test data of the reservoir are used [3], return according to (5) formula, the characteristic parameters a and C of reservoir relative permeability curve are obtained, the corresponding water saturation is obtained from (7) formula according to the water production rate of the well. Finally, the relative permeability test data of the reservoir are interpolated, the relative permeability of water under this yield rate can be obtained [4].

When the oil well is produced at the same time, The law of plane radial flow in homogeneous reservoirs, Bottom hole pressure of water well is:

$$p_{wi} = p_e - \frac{Q_i\mu_w B_w}{1.842\times10^{-3}KK_{rw}(1)h_w}\ln\frac{r_e}{r_w} \quad (8)$$

R_e —oil supply radius of oil well, m;

B_w —formation water volume coefficient, f;

K—absolute permeability of rock, 10-3μm2.

It can be seen from (8) formula, under the same well group, the formation pressure is equal, the production layer is homogeneous and equal thickness, Qi is inversely proportional to ln (re/rw), water injection well and Connected production well Under the same water injection pressure difference, the more water we split, the smaller the equilibrium point Distance injection well. Therefore, the splitting coefficient between the injection well and the production well can be determined according to the location of the equilibrium point [5].

Determination of Splitting Coefficient and Water Injection Rate. Suppose that a water injection well connects to the N production well, the distance between the injection well and the I production well is di, the distance from the water injection well to the equilibrium point is ri, the splitting water is inversely proportional to ln (re/rw) in the case of homogeneous and equal thickness of production layer [6]. The splitting coefficient can be calculated by the following expression:

$$C_{wi} = \frac{1/\ln\frac{r_1}{r_w}}{\sum_{i=1}^{n} 1/\ln\frac{r_1}{r_w}} \tag{9}$$

The distance RI from the injection well to the equilibrium point can be determined by (3) formula. The splitting coefficient with A as the center of the injection well satisfies the relation: sigma (i=1) C_{wi}=1; The splitting coefficient based on the well B of the oil well satisfies the relation formula: $\sum_{i=1}$ Cwi≠1.Fluid production centered on production well B comes from water splitting of each injection well. Because splitting coefficient centered on production well is not equal to 1, it is normalized [7]. Aking an oil well as the center and connecting it with m injection wells, the expression of splitting coefficient centering on the oil well is as follows:

$$C_{oj} = \frac{C_{wj}}{\sum mC_{wj}} \tag{10}$$

The amount of water injected at the center of the injection well is derived from the expression of liquid production separated from the N well:

$$Q_i = \sum_{i=1}^{n} C_{oi}\,(Q_w + Q_O B_o/\rho_o) \times IPR \tag{11}$$

In the formula:

Q_w— daily production water quantity of oil well, m^3/d;

Q_o— oil production per day, t/d;

ρ_o—crude oil surface density, g/cm^3;

IPR—injection production ratio, f.

Determination of Longitudinal Split Coefficient

Dynamic Splitting Equation. Based on the principle of seepage mechanics, the following dynamic splitting equations are proposed by analyzing the dynamic and static factors affecting water injection:

$$C_j = \frac{Y_i}{\sum Y_i} \tag{12}$$

In the formula, Y_i—the small layer split condition value is calculated from the following formula:

$$Y_i = \frac{K_i H_i Z_i G_i K_{shi} N_i}{\ln(D_i)} \tag{13}$$

Formula: K_i—the effective permeability of each injection well, μm;

H_i—the effective thickness of each injection well, m;

Z_i—the connection coefficient of production oil injection well;

G_i—interlayer interference coefficient derived from permeability difference;

K_{shi}—the influence coefficient of sedimentary microfacies;

N_i—water injection into the well corresponds to the production well number;

D_i—oil well spacing, m.

Determination of Water Injection Volume in Small Layer. According to single well distribution water volume and small layer longitudinal splitting coefficient, the amount of water injection in the small layer is calculated by the following formula:

$$Q_j = Q_i C_j \tag{14}$$

Formula: Q_j —the water injection volume of J layer is ,m^3/d;

Q_i —water injection quantity of single well, m^3/d;

C_j —J layer longitudinal splitting coefficient.

Conclusion

Compared with the traditional KH method or H method, this method not only adds static parameters, but also takes into account the relevant dynamic factors. The results are more in line with the actual underground situation. If each block establishes a database the calculation is very convenient, accurate and quick.

References

[1] Huang Xuefeng, Li Jinggong, Wu Changhong, Genghong Xia, Gao Shujuan. Water injection well dynamic partition method of stratified cumulative water absorption [J]. Logging technology, 2004

[2] Ho Sheng Sheng. Reservoir physics [M]. Petroleum Industry Press, 1994

[3] Huang Bingguang, et al. Practical methods of reservoir engineering and dynamic analysis [M]. Petroleum Industry Press, 1998

[4] Ge Jiali. Hydrocarbon reservoir seepage mechanics [M]. Petroleum Industry Press, 1982

[5] Liu Tiemen. Theoretical methods for modeling and optimization of injection-production system [J]. Daqing Journal of Petroleum, 1995

[6] Li Congxin. Optimal operation of large-scale water injection system [J]. Journal of Petroleum, 2001

[7] Wang Naiju. China Oilfield Development Model Theory [J]. Petroleum Industry Press, 1999