CSCanada
Advances in Petroleum Exploration and Development
Vol. 9, No. 2, 2015, pp. 103-105
DOI:10.3968/6854

ISSN 1925-542X [Print]
ISSN 1925-5438 [Online]
www.cscanada.net
www.cscanada.org

The Research for Method to Determine Interpretation Standard of Water Flooded Layer at the High Water-Cut Stage

SHENG Caiwen[a],*; DONG Wei[b]

[a] Research Institute of Exploration and Development of Daqing Oilfield Limited Company, Daqing, China.
[b] No.1 Oil Production Company of Daqing Oilfield Limited Company, Daqing, China.
*Corresponding author.

Received 26 March 2015; accepted 10 May 2015
Published online 30 June 2015

Abstract

This article will contrapose the practical problems that the present interpretation standard of water flooded layer does not adapt to the oilfield development at high water-cut stage. Using relative permeability data of coring well on different types of sand body, establish changing relationship between oil/water relative permeability and standardized water saturation, translate the interpretation standard of water flooded layer divided by water production rate into the interpretation standard of water flooded layer divided by water saturation, and build interpretation standard of water flooded layer respectively on different types of sand body in different oil layers at different blocks, to lay the foundation for the fine interpretation of water flooded layer at the high water-cut stage.

Key words: Relative permeability; Water flooded layer; Water production rate; Water saturation; Sand body type

Sheng, C. W., & Dong, W. (2015). The research for method to determine interpretation standard of water flooded layer at the high water-cut stage. *Advances in Petroleum Exploration and Development*, *9*(2), 103-105. Available from: URL: http://www.cscanada.net/index.php/aped/article/view/6854
DOI: http://dx.doi.org/10.3968/6854

INTRODUCTION

Currently, in the process of oilfield development, oil fields are going into the high water-cut development stage and the water-cut condition in each type of oil layer is serious, making the interpretation of water flooded layer much more difficult. To meet the requirement of oilfield development, the research of integrated interpretation method on water flooded layer is started. At high water-cut period, implementation of the tertiary oil recovery technology to dig potential oil of thick reservoir requires fine hierarchical interpretation, and the object of secondary infilling adjustment has changed into thin and poor layers. How the fine interpretation of water flooded layer proceeds at the high water-cut oil layer, which is the main problem we need face during the oil development. Obviously, the present definition standard of water flooded layer has not been suitable for the need of oilfield development at high water-cut stage. It is necessary to use relative permeability curve to develop interpretation method standard of water flooded layer based on different type of sand body, and determine the corresponding relationship between water saturation and water flooded level. It has provided the basis for the perforation scheme, reservoir engineering calculation as well as the analysis and adjustment of oilfield development.

Water flooded layer has been paid great attention at home and abroad, since it's one of the inevitable problems during oilfield water-flooding development. Generally speaking, oil displacement efficiency and water production rate are used to determine water flooding hierarchy qualitatively and quantitatively. At high water-cut late stage, it is an inevitable trend of the development to determine the interpretation standard of water flooded layer for different types of sand body.

1. THE CLASSIFICATION OF WATER FLOODED LAYER

Using water flooded degree to divide water flooding hierarchy is a quantitative method. There are mainly two kinds of classification methods[1]. One is based on oil displacement efficiency η and the other is based on water production rate F_W. According to the actual data, this article uses water production rate F_W to divide water flooding hierarchy.

The principle of dividing water flooding degree based on water production rate F_W:

$$F_w = \frac{Q_w}{Q_o + Q_w} = \frac{1}{1 + \frac{K_{ro}}{K_{RW}}\frac{\mu_w}{\mu_o}} . \quad (1)$$

Q_o and Q_w—Fractional flow for oil and water respectively;

K_{ro} and K_{rw}—Relative permeability for oil and water respectively;

μ_o and μ_w—Viscosity for oil and water respectively.

K_{ro} and K_{rw} are calculated by empirical equation based on current water saturation of water flooded layers S_w, initial oil saturation of oil layers S_{wb} and residual oil saturation S_{or}.

In Equation (1), water production rate F_W represents the ratio between water production and ultimate production in water flooded reservoir, so F_W can be used to evaluate water flooding degree quantitatively. According to the practical situation and the division criteria of Daqing Oilfield, water flooded degree can be divided as follows:

Oil layer F_W is less than 10%. Low water flooded layer F_W is between 10% and 40%. Medium water flooded layer is between 40% and 80%. High water flooded layer F_W is between 80% and 100%.

2. INTERPRETATION STANDARD OF WATER FLOODED LAYER BASED ON RELATIVE PERMEABILITY DATA

Relative permeability curve is an important basic data for reservoir engineering and reservoir simulation engineering, which is usually measured directly under simulated formation condition. Relative permeability is an important parameter of reservoir. The test results show that the shape of oil-water relative permeability curve, which was obtained from core simulation experiments, mainly depended on rock wettability and pore structure. Measured relative permeability curves are different for cores with different permeability and porosity. For a specific reservoir, since formation samples obtained from cores have different porosity and permeability, the measured relative permeability curves are different. Therefore, choosing several representative relative permeability curves is necessary, and then the relative permeability curves are normalized. Finally, the curves which represent the average relative permeability curve of oil reservoir or layer can be got. For water-wet oil reservoirs, the relative permeability curve of oil-water two phase flow can be expressed by the following empirical formula[2-4]:

$$K_{ro} = \alpha\,(1 - S_{wd})^m , \quad (2)$$

$$K_{rw} = \beta S^n_{wd} , \quad (3)$$

$$S_{wd} = \frac{S_w - S_{wi}}{1 - S_{wi} - S_{or}} . \quad (4)$$

K_{ro}— Relative permeability of oil, a function of S_w;

K_{rw}— Relative permeability of water, a function of S_w;

S_{wd}— Standardized water saturation;

S_w— Water saturation;

S_{wi}— Irreducible water saturation;

S_{or}— Residual oil saturation;

α— Relative permeability of oil $K_{ro}(S_{wi})$, when $S_w = S_{wi}$ and $S_{wd} = 0$;

β— Relative permeability of water $K_{rw}(S_{wi})$, when $S_w = 1\text{-}S_{or}$ and $S_{wd} = 1$.

Calculate the common logarithm of both sides of Equations (2) and (3):

$$\lg K_{ro} = a + m\lg(1\text{-}S_{wd}), \quad (5)$$

$$\lg K_{rw} = b + n\lg S_{wd}, \quad (6)$$

$$a = \lg \alpha, \text{ or } \alpha = 10^a, \quad (7)$$

$$b = \lg \beta, \text{ or } \beta = 10^b. \quad (8)$$

m and *n*— Constant depend on rock wettability and pore structure.

Seen from Equations (5) and (6), for the oil-water relative permeability curve data of a specific sample, if the corresponding data of K_{ro} plotted on log-log paper has high linearity with $1\text{-}S_{wd}$, so does K_{rw} with S_{wd}, the value of *α, β, m* and *n* can be obtained respectively, after linear regression.

The following equation is given by Equation (4):

$$S_w = S_{wi} + S_{wd}\,(1\text{-}S_{wi}\text{-}S_{or}). \quad (9)$$

The relative permeability curves of each sample in each unit are made by using existing core data of different types of sand body. Meanwhile, linearly fit the specific parameters of the oil-water relative permeability formula expression for each sample in each unit and then calculate the average of parameters, which are the fitting parameters of oil-water relative permeability expression in this layer. Variation trend of water saturation can be obtained by using the relation between water saturation and standardized water saturation. Similarly, the relation between oil-water relative permeability and standardized water saturation can be also obtained. Then standardized relative permeability curve can be given by the relation between the water saturation and oil-water relative permeability.

Combined with the water production rate formula, Equation (1), the standard of water flooded layer divided by water production rate can be translated into water saturation, as following equation.

$$\frac{(1 - S_{or} - S_w)}{(S_w - S_{wi})^n} = \frac{\mu_o}{\mu_w}\frac{\beta}{\alpha}\frac{1 - F_w}{F_w}(1 - S_{wi} - S_{or})^{(m-n)} . \quad (10)$$

Based on the data of sealing core well, interpretation standard of water flooded layer on different types of sand body in different oil layers of different blocks can be built respectively. In each oil layer of South Block 1, the division standard of water flooded layer of channel sand is shown in Table 1.

Table 1
The Standard of Water Flooded Layer of Channel Sand in Each Oil Layer of South Block 1

Oil layer	Degree	High	Medium	Low	Non
	F_w	**0.8-1**	**0.4-0.8**	**0.1-0.4**	**< 0.1**
S1	S_w	0.35-0.76	0.27-0.35	0.24-0.27	< 0.24
S2	S_w	0.47-0.85	0.39-0.47	0.37-0.39	<0.37
P1	S_w	0.32-0.67	0.18-0.32	0.12-0.18	<0.12
P2	S_w	0.32-0.67	0.21-0.32	0.17-0.21	<0.17

The standard is used for fine interpretation with different types of sand body in each oil layer of research area. At present, this standard has been applied in production.

CONCLUSION

On the basis of analyzing water flooded layer feature, this article has discussed the relation between oil-water relative permeability and water saturation as well as the relation between irreducible water saturation and residual oil saturation in different types of sand body. Furthermore, in different type of sand body of Sazhong development area, quantitative identification standard of water flooded layer has been built, which provides the basis for well logging interpretation, perforation scheme, reservoir engineering calculation as well as analysis and adjustment of oilfield development.

REFERENCES

[1] Yong, S. H., & Zhang, C. M. (2002). *Logging data processing and integrated interpretation* (pp.351-352). Shandong, China: China University of Petroleum Press.

[2] Chen, M. F., LÜ, Y. H., & Yang, Q. R. (1998). Research of reservoir water flooding condition using the relative permeability data. *Fault-Block Oil & Gas Field*, *5*(5), 26-29.

[3] Jiang, B. J., Tang, H., & LÜ, D. L. (2006). Water-yielding pattern of the thin layer of bottom water reservoir relative permeability curve is used to study water-yielding pattern of thin oil reservoir with bottom water using the relative permeability curve. *Xinjiang Petroleum Geology*, *27*(5), 588-590.

[4] Xie, J. Z., & Wu, X. L. (2004). Estimating oil-water relative permeability curve using production logging data. *Petroleum Exploration and Development*, *31*(2), 64-66.