Relative Permeability Research of XX Block in Nanpu Oilfield

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Abstract. The research of relative permeability curve plays an important role in guiding water injection development of reservoir. Through the indoor oil-water relative permeability experiment, we get the natural core of relative permeability data of 1-5 of Nanpu oilfield, and draw out the relative permeability curve, then block the relative permeability curve of normalized processing. Analyzing the experimental data from all aspects and it reflects the characteristics of the reservoir of relative permeability: wettability of Nanpu oilfield reservoir rock has strong hydrophilic characteristic, two phase percolation in Nanpu 1-5 are relatively narrow, and residual oil in the water phase permeability is low, all above show that the pore connectivity is poor. Results are a certain reference significance in the development of XX blocks of Nanpu oilfield.

Keywords: Nanpu oilfield; relative permeability experiments; normalization.

1. Introduction

Relative permeability curve is the basic data of multiphase percolation, it has great significance in the oilfield development to the dynamic analysis and reservoir numerical simulation [1-4]. In view of the natural core of Nanpu oilfield through the experiment, it concludes that it gains characteristics of relative permeability curve in the XX block, analyses the various factors of the influence in the relative permeability curve, and studies in the reservoir characteristics and production rules reflected by relative permeability curve.

2. Regional Overview

XX block of Nanpu of is located in the south-western flank of the structure of Nanpu no. 1, which is a buried hills lie anticline structure complicated by fault. It shows the north east to faulted anticline, the formation from north to south is gradually rise, and it breaks to be fault nose and fault block traps by the fault of NE, NW and EW direction. From bottom to top, the range of the trap and the area is reduced. Member 1 of east formation is for the main purpose of the study, and all the samples taken from the east reservoir.

3. Phase Permeability Experiment

3.1 Experimental Fluid

Table 1. Formation water salinity data

Main ion content/(mg)							Salinity/(mg L^{-1})
K+	Na+	Ca2+	Mg2+	Cl-	SO42-	HCO3-	
2705	6024	678	999	15955	1940	306	28606

Formation water used in the experiment is simulation formation water based on the reservoir formation water salinity of configuration characteristics, ion content and formation water salinity parameters of simulation formation water are shown in table 1. The viscosity of simulated formation water is 0.4768mPa•s, the density is 1.147g/ cm ³; Experimental oil is simulated oil, its viscosity is 6.022mPa•s, and density is 0.845g/cm ³. Simulated formation water and model oil seal saved after using micro-porous membrane filter.

3.2 Core Experiment

In XX block of Nanpu east section, lithology is mainly fine sandstone, followed by the sandstone, anisometric sandstone and small amounts of coarse sandstone and siltstone, with fine sandstone mainly argillaceous cementation, lithology is loose, the local mud gravel sandstone and siltstone often contain shale stripe, local chip containing carbon.

Table 2. XX block core basic parameters

Sample number	Length (cm)	Diameter (cm)	Φ (%)	Kg (×10-3μm2)	Swc	Ko(Swc)
1	5.35	2.51	25.1	264	45.9	113
2	6.31	2.51	24.9	401	60.6	53.8
3	6.24	2.51	23	41.8	15	60.6
4	5.39	2.51	22.6	41.8	55.1	9.06

3.3 The experimental process

Experiments using the unsteady method determine the oil-water relative permeability core sample, in order to simplify the experiment process, the experiment under the temperature of 25℃, the main experimental steps:

Clean the core after drying, weighing the dry weight, vacuum saturation simulated formation water, get the effective porosity is obtained after the wet weight.

By simulating the formation water in oil displacement core only at the core is no longer water, irreducible water saturation is determined.

Place the core for a period of time, recovery the core wettability.

The unsteady constant speed method is adopted, with appropriate displacement speed experiment of water flooding, record every time water rate, oil production and the displacement pressure difference, until the export moisture content over 99% or after water injection pore volume for more than 30 times, the determination of residual oil in the water phase permeability, the experiment to the end.

3.4 The experimental results

Through the above four core test, the test result is shown in fig.1.

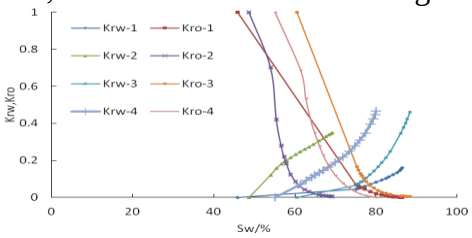

Fig.1 permeability test results of XX block of Nanpu

4. Phase Permeability Data Processing

4.1 Relative Permeability Normalization

For a specific reservoir, because the physical properties of the selected samples are not completely consistent, the analysis of the core sample with different porosity and permeability, as well as the test environment, so the relative permeability curve measured is different, Therefore, if choose a sample optional of relative permeability curve as the representative of the whole reservoir for the calculation of reservoir numerical simulation is not reasonable.

Chen put forward correct method should be in accordance with the characteristics of the reservoir, on the basis of different permeability and porosity, choose several representative relative permeability curve, based on the normalized processing, so as to be able to represent the average relative permeability curve of oil reservoir. The total four samples were collected for relative permeability experiments. According to the four samples of relative permeability experimental data normalization processing.

4.2 Establishment of the Relative Permeability Normalization Equation

The definition and expression of standardization of oil-water relative permeability [5-7]:

$$K_{rw}^{*} = (S_{w}^{*})^{a} \quad (1)$$

$$K_{ro}^{*} = (1 - S_{w}^{*})^{b} \quad (2)$$

In the formula

$$K_{rw}^{*} = K_{rw} / K_{rw}(S_{or}) \quad (3)$$

$$K_{ro}^{*} = K_{ro} / K_{ro}(S_{wi}) \quad (4)$$

$$S_{w}^{*} = (S_{w} - S_{wi}) / (1 - S_{wi} - S_{or}) \quad (5)$$

Standardization of oil-water relative permeability of the logarithmic relationship with effective wetting phase saturation.

Equation (1), (2) on both sides of the exponential, we can get:

$$\lg K_{rw}^{*} = a \lg S_{w}^{*} \quad (6)$$

$$\lg K_{ro}^{*} = b \lg(1 - S_{w}^{*}) \quad (7)$$

Meanwhile, rewrite formula (3), formula (4) and formula (5), get

$$K_{rw} = K_{rw}^{*} \bullet K_{rw}(S_{or}) \quad (8)$$

$$K_{ro} = K_{ro}^{*} \bullet K_{ro}(S_{wi}) \quad (9)$$

$$S_{w} = S_{w}^{*}(1 - S_{wi} - S_{or}) + S_{wi} \quad (10)$$

In the formula:

K_{rw}^{*}——Standardize the relative permeability of water, decimal.

K_{ro}^{*}——Standardize the relative permeability of oil, decimal.

S_{w}^{*}——Standardized water saturation, decimal.

K_{rw}——The relative permeability of water, decimal.

K_{ro}——The relative permeability of oil, decimal.

S_{w}——Water saturation, decimal.

S_{wi}——The irreducible water saturation, decimal.

S_{or}——Residual oil saturation, decimal.

$K_{rw}(S_{or})$——The residual oil saturation of water relative permeability, decimal.

$K_{or}(S_{wi})$——Relative permeability of oil under irreducible water saturation, decimal.

a, b——constant.

4.3 relative permeability normalized application methods

a. All the relative permeability curve calculated Swi, Sor, Kro(Swi), Krw(Sor), which has the geometric average.

b. According to the formula (3), formula (4), formula (5), and calculate all the standardization of relative permeability curve of relative permeability curve. Namely according to each of the relative permeability curve of Sw, Kro, Krw to calculate $S_{w}^{*}, 1 - S_{w}^{*}, K_{ro}^{*}, K_{rw}^{*}$.

c. According to each of the standardized data of relative permeability curve, in terms of the formula (6), (7) linear regression, and obtained the values of a and b, and obtain the geometric mean values of a and b.

d. In the range of 0 ~ 1.0 from small to large, the standardization of different water saturation values S_{w}^{*} given by the formula (1), (2) to calculate the relative permeability, standardization value K_{ro}^{*}, K_{rw}^{*}.

e. Take geometric average be calculated in step 1 of the Swi, Sor, Kro (Swi), Krw (Sor)into formula (8), (9) and (10), and use the $S_{w}^{*}, K_{ro}^{*}, K_{rw}^{*}$ calculated in step 4 to get the value of average relative permeability curve Sw, Kro, Krw.

5. Experiment Results and Analysis

Look from the curve of the normalized, Nanpu XX block has high irreducible water saturation, is 52.6%. Rock wettability can be judged from the relative permeability curve, oil and water relative permeability curve of hydrophilic rock of isotonic point (X type curve intersection) from water saturation 50% shift to the right, and when it was more oleophylic, the oil-water relative permeability curve isotonic point from the water saturation 50% offset to the left. In the middle, Wetting has both the common characteristics. From fig. 2 draw isotonic point water saturation is higher than 50%, it is about 70%, shows the strong hydrophilic characteristics. Two phase flow range 50% ~ 81.1%, the span is 31.1%, two phase percolation with relatively narrow. When residual oil water relative permeability is 0.3689, shows the pore connectivity is poor.

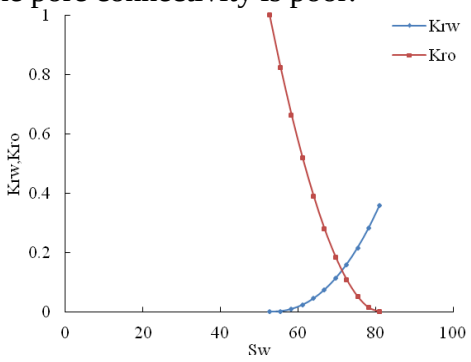

Fig. 2 Nanpu XX block normalization relative permeability curve

6. Conclusion

(1) Carbonate phase permeability experiment shows that the carbonate reservoir is a strong water wet reservoirs, the width of two phase zone is narrow, and the water phase permeability under the residual oil saturation in Nanpu XX block on the low side.

(2) The normalization of relative permeability curves reflect reservoir after water breakthrough, has a rapid rise in oil phase and water phase, the residual oil in the water phase permeability is higher, show reservoir percolation characteristics of low permeability, low viscosity, hydrophilic;

(3) Oil production index after water breakthrough are falling fast, producing fluid index region is narrow, only in 40% ~ 80% aqueous interval; Overall liquid producing capacity is low, middle and high water cut period can appropriate solution.

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