Study on Factors Influencing Electric Resistance of Cores

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Abstract

The experimental study on determinants of the standard curve of resistance-oil saturation has been put on the agenda firstly, as researching the relation between resistance and oil saturation. Influential factors mainly referred to permeability, porosity, electrode spacing, different displacing media and their concentrations. Indoor tests were conducted to ascertain what above factors put on the electric resistance. The study has revealed that: to homogeneous cores, the greater the permeability, the lower the resistance value; The resistance value has risen along with consistently expanding electrode spacing; The slight alteration of resistance was actually negligible as concentrations of the displacing medium fluctuated; Maintaining residual conditions the same, the standard relation of resistance-oil saturation has correlated with permeability only if identical compound formation water existed in various displacing media.

Keywords

Electric resistance; Permeability; Electrode spacing; Displacing media; Saturation

1. Introduction

The experimental block is characterized by loose reservoirs, poor cementation, favorable physical property[1], where crude oil pertains to heavy oil. The research block was under a temperature of 65℃ [2], salinity of 9374.13mg/L, and permeability around 20～5000mD.

In order to acquire vertical and planar change laws of oil saturation formed under different chemical displacing model in the reservoir, previous to setting out the standard curve of resistance-oil saturation[3-4], we attempted experimentally to confirm effects on measuring the resistance value exerted by permeability, porosity, electrode spacing, different displacing media and their concentrations, through measuring resistance values which has been reckoned as an usual method to acquire oil saturation, integrated with studies on certain litho-electrical determinant like ion proposed by relevant researchers[5-8]. Take specific geological settings in the block of destination into account, the temperature and salinity were kept as fixed values, whose impression on the standard relation of resistance-oil saturation of seaborne heavy oil were negligible.

2. Experimental Section

2.1 Main materials and equipment

Combining investigation data at home and abroad with filed applications, we selected compounds from HNT300 as hydrophobic associating polymer solutions provided by the offshore oilfield, the surfactants from BH-M2 prepared by polyoxyethylene octylphenol ether TX100 and sulfonate gemini surfactants in the proportion of 1:4, tested cores as: casting cube cores in the length of 45mm, and the cores of 50mm×45mm×300mm.

Water consumed in the saturation model, preparation for compound solutions and the binary composite system was the stimulated formation water in CNOOC. The formula of stimulated formation water was shown in Table 1.

Table 1 Ion Contents in Experimental Stimulated Water

Ion Contents(mg/L)							TDS (mg/L)
Na^+、K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	
3091.96	158.68	276.17	5436.34	85.29	311.48	14.21	9374.13

Main equipment: electrodes, beakers, vacuum pumps, duplex automatic incubators in the control accuracy of ±1℃; the tranquil flow pump LB-1 made in Beijing Satellite Manufacturer; thermostat magnetic stirrers in the type of WCJ-801, resistance measuring device, valves, pipelines, etc.

2.2 Methods of experiment

Measuring electrical resistance in different permeability and porosity

Adopted casting cube cores in length of 45mm, owing permeability respectively as 500×10-3μm2、1500×10-3μm2、3500×10-3μm2、4500×10-3μm2, laid two pairs electrodes at both terminals of the injection and production, evaluated cores and saturated them with formation water, cured in the incubator for 24h, injected formation water applied for displacing into cores owing different permeability, afterwards measured stable resistance values. The experimental temperature: 65℃.

Measuring electrical resistance in different electrode spacing.

Adopted homogeneous cores in the size of 50mm×45mm×300mm, evaluated cores and saturated them with formation water, cured in the incubator for 24h, connected electrodes as Figure 1. The resistance values in four sorts of electrode spacing were available (10mm、20mm、30mm and 60mm). The experimental temperature: 65℃.

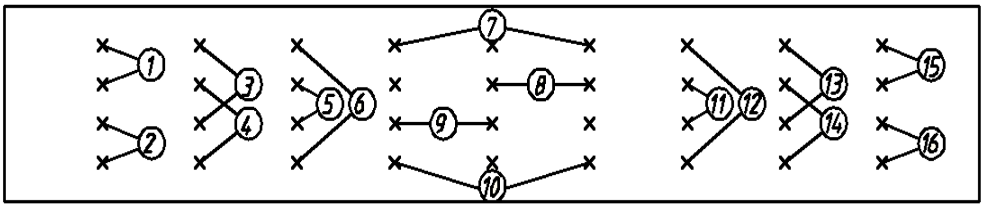

Figure 1 Connected Schematic Diagram of Electrodes

Measuring electrical resistance in different displacing media.

Added equivalent HNT300 polymer solutions under different concentrations into beakers, inserted electrodes beneath the solution, subsequently measured the resistance value by resistance measuring device. The experimental temperature: 65℃.

By means of static testing, respectively selected stimulated formation water, polymers and the binary system(2000mg/L HNT300+0.3%BH-M2) as displacing media, injected into casting cube cores of 45mm with identical permeability, then measured static resistance values.

The experimental temperatures were all set as 65℃.

3. Results and Discussion

3.1 Influences held by permeability and porosity,

Injecting stimulated formation water into cores owing different permeability, the stable resistance values were shown as followed:

It has been revealed in Figure 2 that permeability of cores did possess impacts on the resistance while maintaining others identical. To homogeneous cores, the higher the permeability, the less resistance values, for which higher permeability meant better pore connectivity, and shorter directional distance as waterborne ions discharging, the stronger conductivity and the less resistance values, at the same concentration of saturated waterborne ions.

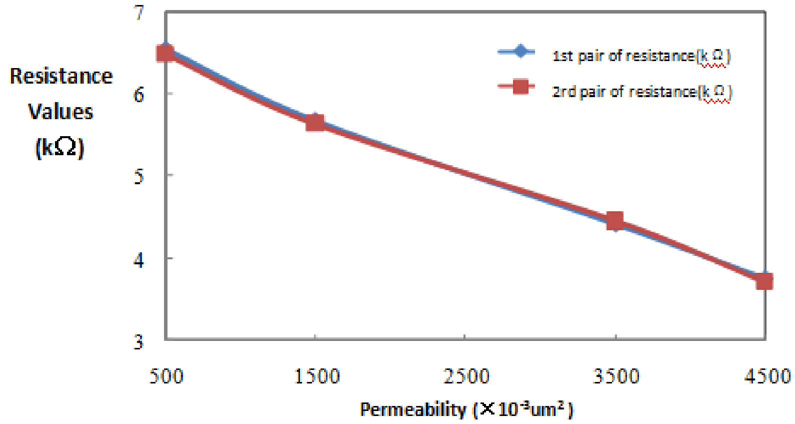

Figure 2 Resistance Values of Both Injection-Production Terminals in Cores with Different Permeability

3.2 Influences by electrode spacing

Under different electrode spacing, the stable resistance values were measured as followed:

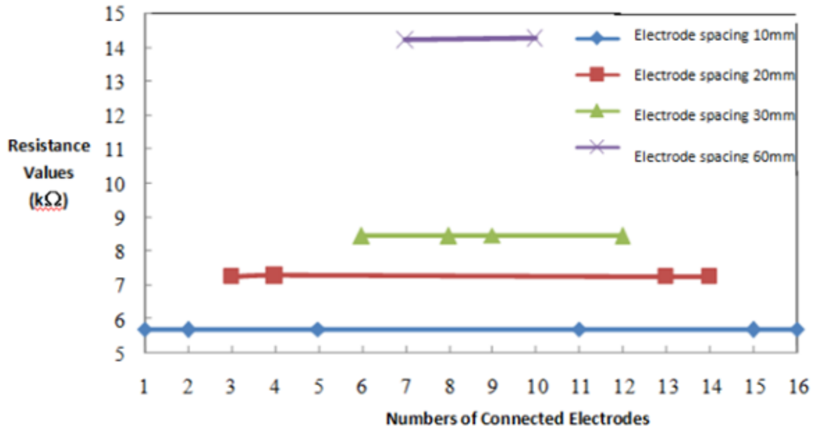

Figure 3 Resistance Values Measured Under Different Electrode Spacing

The figure showed that electrode spacing did put effects on the electric resistance. Not remarkable alterations the resistance presented under identical spacing, while above data indicated that resistance grew along with expanding spacing, for which shorter orienting distance the waterborne ions moved and subsequent weaker conductivity brought about greater resistance.

3.3 Influences by displacing media.

At diverse concentrations of polymers, the electric resistance was measured as followed: media varied, of whom negligible fluctuation range was between 0.390 and 0.395. Furthermore, the fluctuated concentrations of displacing media would not alter the resistance value.

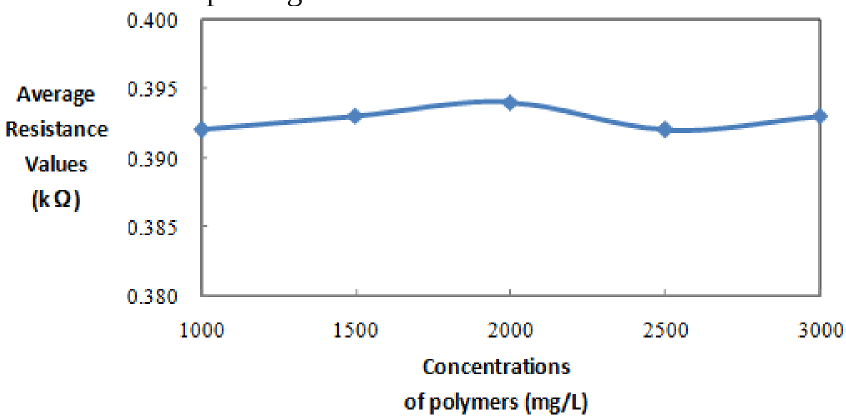

Figure 4 Average Resistance Values under Different Concentration of Polymers

Under different displacing media, the resistance value was measured as followed:

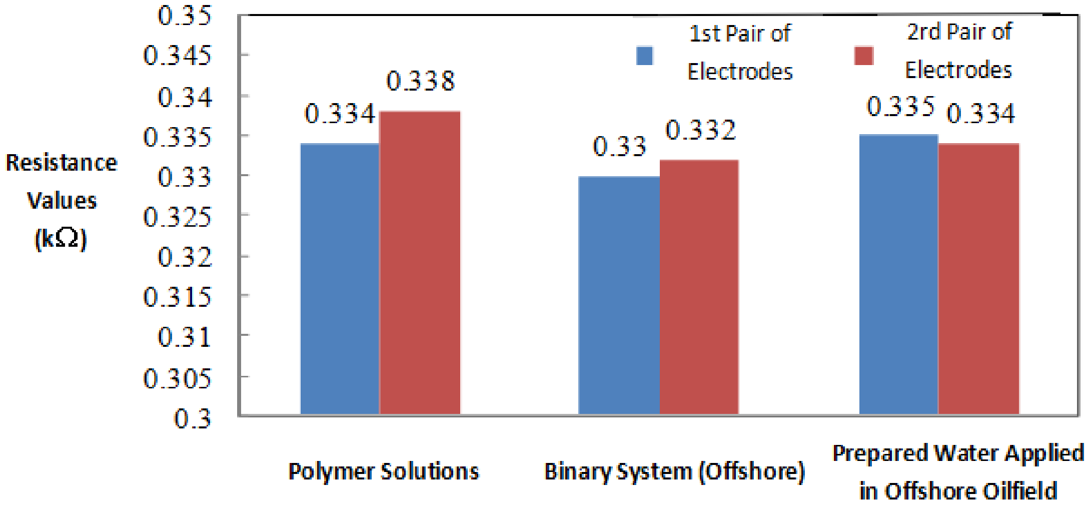

Figure 5 Resistance Values of Both Injection-Production Terminals under Different Displacing Media

It worth noting in the figure that different displacing media put tiny impacts on resistance values of both injection-production terminals. The resistance values of displacing media had something to do with prepared water as maintaining others stable. The standard relation of resistance-oil saturation correlated with permeability under identical prepared formation water.

4. Conclusions

(1) The permeability and porosity carry weight on electric resistance measured, exactly that the higher permeability the cores owing, the better the pore connectivity turns, the less measured resistance values.

(2) The electrode spacing has an effect on electric resistance measured,, meaning resistance values multiply as the spacing extending constantly.

(3) The tiny fluctuation range of resistance values can be ignored while the concentrations of displacing media altering, in another word, the changeable concentrations of displacing media never make a difference in the resistance value.

(4) Different displacing media hold little impact on resistance values of both injection-production terminals. The resistance value of displacing media merely associate with prepared water as maintaining preconditions consistent.

Reference

[1]Li Yanting, Lin Meili , DU Xin, Ju Weilon. The development index research of Bei 301 block[J]. Petrochemical Industry Application, 2010, 01:39-41.

[2]Jiang Youwei, Zhang Yitang, Liu Shangqi, Guan Wenlong, Chen Yaping, Liu Shuangmao. Displacement mechanisms of air injection in low permeability reservoirs[J]. Petroleum Exploration and Development, 2010, 04:471-476.

[3]Gu Yonghua ,He Shunli ,Tian Ling, Lv Zhikai .Air injection to improve recovery efficiency numerical simulation research[J]. Journal of Chongqing University of Science and Technology (Natural Sciences Edition), 2010,05:82-84+87.

[4] KUMAR V K,GUTIERREZ D,CANTRELL C.30 years of successful high - pressure air injection: performance evaluation of Buffalo Field,South Dakota[C]//SPE Annual Technical Conference and Exhibition,19-22 September 2010,Florence,Italy.

[5] GREAVES M , REN S R,RATHBONE R R , et al . Improved residual light oil recovery by air injection (LTO process) [C] / /Annual Technical Meeting ,Jun 8-10,1998,Calgary,Alberta.

[6] FASSIHI M R , GILLHAM T H . The use of air injection to improve the double displacement process [C]//SPE Annual Technical Conference and Exhibition , 3-6 October 1993, Houston, Texas.
[7] FASSMI M R, YNNIMARAS D V , KUMAR V K. Estimation of recovery factor in light-oil air injection projects[J].SPE Reservoir Engineering , 1997 , 12(3) : 173-178.
[8] GREAVES M, REN S R, XIA T X.New air injection technology for IOR operations in light and heavy oil reservoirs [C] / / SPE Asia Pacific Improved Oil Recovery Conference , 25-26 October 1999 , Kuala Lumpur , Malaysia.