Research Status of the Effect of Changes in Oil Pore Structure of Polymer Flooding

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Abstract

As the domestic demand for oil and gas resources is increasing, it is the current main task to improve the oil recovery as large as possible, with the development of technology, people has confirmed that in certain conditions, polymer flooding can greatly improve the efficiency of oil displacement, and pore structure of reservoir rock is a major factor in the exploitation of oil and gas resources, it will also affect the flowing and properties of polymer in the process of polymer flooding, which affect the efficiency of polymer flooding. Pore structure were reviewed in this paper, the research status and research status of polymer flooding, and has a guiding significance for oilfield and better development.

Keywords

Pore Structure; Polymer Flooding; Rock.

1. Introduction

Oil is non-renewable resources, but with the development of world economy, all countries on oil consumption continue to increase. The rapid economic development since China's reform and opening up, the consumption of oil to grow with each passing day, the oil gap is more and more big, in 2005, an annual output of 182 million tons of crude oil in our country, the consumption of 318 million tons. It is predicted that China's oil gap to 2020 will reach 300 million tons. Petroleum strategic and security issues related to national economy and people's livelihood, people pay more and more attention. However, more and more difficult to add oil reserves, mined reservoir quality is getting worse and worse, and therefore maximize oil recovery rate has been a major issue oilfield oil research.

However, the core pore structure characteristic is the main impact on the reservoir capacity and recovery. Especially, the multiphase flow is related to the temperature, pressure and interreaction between the fluid and the rock. What is more important, it is also related to the microscopic pore structure of core. Therefore, making clear the micro pore structure of reservoir rock and studying the distribution of the reservoir pore size, pore throat ratio, which has very important practical significance to study of the effect of polymer flooding, enhanced oil recovery, achieve sustainable development and improve economic efficiency oil fields.

2. Pore Structure Classification

The reservoir space in the rock is a complicated 3D pore network system. In this space, in accordance with the fluid flow process and storage divide pore and throat pore into two parts. Surrounded by the rock skeleton and effecting fluid storage is pore. While connecting the pores, and the pore connectivity plays an important role as the throat. There are many kinds of classification methods of pore, mainly according to the pore origin points, the pore size, pore connectivity status [1].

(1) According to the pore origin points

(a) Inter granular pore: Refers to the pore space between clastic particles, matrix and cements; (b) Micro pore: the pore radius less than 0. 5μm is micro pore;(c) Dissolved pores: Is the formation of inter granular pore corroded after the pore, including particles dissolved pore, dissolved pore, dissolved pore in the cement and so on;(d) Micro crack: during digenetic process, formed by the

contraction function or action of tectonic stress of rock itself, cut through the rock, and even cut through the debris particles themselves gap.

(2) According to the pore size

(a) Super capillary pore: pore radius and the width of crack are larger than 250μm. Under natural conditions, the fluid can flow freely in the capillary pores; (b) Capillary pore: pore radius in the width of 250 μm~0. 1μm, fissure in 250 μm~0. 1μm. Fluid in the pores, due to capillary force, cannot flow freely among them, only when the force is greater than the capillary resistance, fluid can flow; (c) Micro capillary pore: pore radius of less than 0. 1μm, slit width of less than 0.1μm.Under normal temperature and pressure conditions, the fluid in the pore, has no free flowing.

(3) According to pore connectivity status

(a) Effective porosity, the aperture radius, in more than 0.1μm, are communicated with each other, and the fluid can flow in the pore space in natural condition;(b) Invalid pore (or "dead rock pore") is the isolated, unconnected porosity and capillary porosity.

The pore structure of the reservoir is the main factor on the reservoir capacity of fluid and on the exploration of the oil and gas. Therefore, figuring out the rock pore structure characteristics is the key to EOR. Especially, the distribution of pore geometry and reservoir fluid in pores plays an important role in the exploration and development of oil and gas [2].

3. Pore structure of the research methods

The methods of studying pore structure characteristics mainly include three categories: direct observation, indirect observation and digital core method. The first method includes cast thin section, scanning electron microscopy, image analysis, various fluorescent display injection methods and so on; The second method contains NMR and capillary pressure curve method (mainly including the semipermeable membrane method, mercury and centrifuge method) and so on; The third method mainly refers to the pore structure of 3D model reconstruction technology. However, at present, capillary pressure curve method, casting pore structure characteristics of thin section of rock are the most widely used in indoor experiment to describe and evaluate the rock pore structure characteristics [3-5].

Cast thin section, which is simple and intuitive, can obtain the core porosity, pore, throat, coordination numbers and detrital composition through directly observing pictures. Scanning electron microscopy can analyze the pore throat, the types of clay minerals and its existing forms, while environmental scanning electron microscope can directly analyze the changes of microscopic pore characteristics of samples in the case of oil or water [6]. Conventional mercury injection can research the pore structure of reservoir, through the capillary curve, analysis of parameters to characterize pore throat size, sorting, connectivity and permeability. The rate controlled mercury penetration, due to the experimental process is quasistatic, pore and throat can be distinguished, and the measurement is closer to the static capillary pressure, throat radius closer to the real situation.

4. Research status of polymer flooding

Polymer flooding is a tertiary oil recovery technology developed in the early 1960s, which is characterized by the high molecular weight polymers added to the water, so that it increases the viscosity, improve flooding mobility ratio between displacing phase and displaced phase, expand swept volume, improve oil recovery. In-depth study of polymer flooding, which has important significance to improve the effect of oilfield development, maintain stable production of crude oil and improve the ultimate recovery of crude oil[7].

The United States began a related laboratory study in the 1950s, conducted the first field tests in 1964, more than 60 field test were conducted until 1969, and the vast majority of them are successful. Due to the reasons of imperfect surface treatment process and improper polymer selection result in problems of injectability, some trial halfway terminated. From 1970 to 1985, the United States has conducted 183 polymer flooding pilot test, all the tests have received economic benefits. Although

some trials did not improve recovery, but it still achieved some economic benefits because of economic policy. Because of the smaller amount of polymer (46mg / L • PV) reasons, flooding polymer flooding enhanced oil recovery value is generally less than 5% after water. In addition, the former Soviet Union, Canada, France, Germany, Oman and other countries have also carried out earlier industrial test of polymer flooding, polymer dosage increased to 123-729mg / L • PV, and achieved 6% -17 EOR % effect. From the 1970s, after a long research and a lot of practice, China Petroleum Science and technology workers achieved many achievements and breakthrough progress in the study on the oil of polymer flooding, the concept of polymer flooding has been changed.

The late 1980s, because of industrial policy and the reason oil prices, foreign reduced polymer flooding technology research and application, due to polymer flooding reduced the water/oil mobility ratio, improved injection profile, expanded swept volume, reduced the adverse impact caused by the heterogeneity of the reservoir and improved recovery, so it was watched generally in the world, the overseas petroleum scientists have done a lot of theoretical and experimental research [8-13].

In China, Daqing Oilfield conducted the research of polymer flooding technology early. Laboratory study began in early 1970s, developed rapidly after 1990s, was applied large-scalely in 1996, the current total oil production has more than 100 million tons. Daqing oilfield applied successfully polymer flooding technology in period of extra high water cut of composite water cut beyond 90%, achieved better than water flooding recovery efficiency up to 10%, made a lot of research and practical experience, and achieved a major breakthrough in the understanding of polymer flooding oil technology theory[34-37]. Daqing Oilfield polymer flooding technology have some characters ,such as large scale, high technology content, good economic and so on, create the miracle on the history of the development of oil fields in the world, a number of techniques have been advanced in the world. Shengli, Dagang, Henan, Liaohe Oilfield also successfully applied polymer flooding technology, and plenty of high-temperature, high salinity oil, polymer flooding production in the whole field production are a considerable proportion.

All these research results, the study of theory of polymer flooding had the new breakthrough, produced a qualitative leap. At present, more and more people believe that polymer flooding not only expanded swept volume, but also improve oil displacement efficiency, but for both the contribution of polymer flooding to improve oil recovery is still unclear. Although polymer flooding in the country has formed a relatively complete supporting technology, the theory has also made a major breakthrough, but the problems are gradually increasing.

References

[1] He Gengsheng.Reservoir physics[M]. Beijing: Petroleum Industry Press, 1994200-207.

[2] Xu F, DongP. Fractalapproach to hydraulic properties in unsaturated porous media [J]. Chaos Solutions & Fractals, 2004, 19(3): 327-337.

[3] Dmitry B.Silin,etal. Robust determination of the pore space morphology in sedimentary rocks,paper SPE 84296,presented at the SPE Annual Technical Conference and Exhibition, Colorado, October,5-8,2003.

[4] Pape,H.Clauser,C. Iffland, J.Variation of permeability with porosity in sandstone diagenesis interpreted with a fractal pore space model.Pure and Applied Geophysics,2000,157(4): 603-619.

[5] Krohn,C. E.Sandstone fractal and Euclidean pore volume distributons.Journal of Geophysical Research,1988,93(B4): 3286-3296.

[6] Liu Weixin, Cheng Qiuquan, Wang Yanbin, etal.Oil and gas reservoir characteristics of microscopic analysis technology and its application[J]. Experimental petroleum geology, 2006, 28(5): 341-343.

[7] Jiang Jishui, song Jishui. Improve oil recovery [M]. Petroleum Industry Press, 1999:2-10.

[8] VanPoollenHK,etal. Steady-state and Unsteady-state Flow of Non-Newtonian Fluids throught Porous Media[J]. SPE,1969,80-88.

[9] K. S. Sorbie,LJ. Roberts. A Model for calculating polymer injectivity including the effects of sheared gradation[J]. SPE,1984,15-18.

[10] D. G. Clark, T. D Van Golf-Racht. Pressure-Derivative Approach to Transient Test Analysis [J]. A High- Perme_ability North Sea Reservoir Example, JPT, 1985, 2023-2039.

[11] L. P. Dake. Fundamentals of Reservoir Engineering[M]. Amsterdam: Elsevier Scientific Publishing Company,1978.

[12] Ruddy,Anderson,M. A,Pattillo,P. D,Bishiawi, M and Foged, N. Rock Compressibility, Compaction and subsidence in a High Porosity Chalk Reservoir [J]. JPT,1989,741-749.

[13] Richardson,TX. Society of Petroleum Engineers [J].SPE, 1984