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Study and application of a new blockage remover in polymer injection wells

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ABSTRACT

With the extensive application of polymer flooding technology in offshore oilfields, the plugging in polymer injection wells has become more and more severe, which seriously affects the oil displacement effect and regular production of oilfields. In this paper, a new kind of blockage remover has been developed and evaluated by rheological behavior experiments, dissolution experiments and core flooding experiments. The results reveal that this new blockage remover can effectively reduce the viscosity of polymer and completely degrade the reservoir blockage with low corrosion rate. It is beneficial to long-term production of oil wells in offshore oilfield. Results of core flooding experiments show that this new blockage remover can relieve polymer damage and improve permeability. The agent has been applied in LD10-1 oilfield in 2016, the daily injection rate increased significantly after stimulation.

1. Introduction

With the continuous development of Bohai oilfield, polymer flooding technology has become one of the most important methods to stabilize and increase oil production in offshore heavy oilfields [1,2]. However, the high viscosity of polymer solution and the adsorption (or trapping) of polymer in the pores of formation can easily lead to increase of injection pressure and decrease of injectivity. On the other hand, with high temperature, high pressure, complex biological and chemical conditions, the polymer will form a blockage which can block the pores of reservoir. In particular, the hydrophobic associative polymer used in SZ36-1 Oilfield is characterized by its viscosity, poor solubility, the blockage caused by this polymer is difficult to relieve and seriously affects the production of oilfield.

Many methods of plugging removal have been reviewed [3] in order to enhance the polymer injectivity in damaged wells. Physical blocking removal technology is using various vibration or pulse generated by the shock wave to make blockages loosing and falling off, then producing micro-fracture in near wellbore area [4]. However, the physical blocking removal technology is characteristic with complex stimulation process, short plugging radius and difficulty of control. Meanwhile, the offshore platform is limited to the conditions of site, well structure and equipment, and hard to put into practical use. Biological plugging removal technology can effectively degrade the long chain of polymer by microbial metabolism of surfactant, enzyme [5]. However there are strict requirements for enzyme and this technology is still at research stage and not mature enough for field application. Chemical plugging removal technology is relatively mature for field application. It can degrade polymer easily by strong oxidant, acid or surfactant [6,7]. But the validity of those chemical agents is only a few months, and there are some potential safety hazards which are not conducive to the long-term production of offshore oil fields.

A new type of blockage remover which consists of cleaning agent, degradation agent and multi-hydrogen acid system was

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developed. The removing mechanism and basic performance of this new blockage remover were analyzed and evaluated based on the experiment results.

2. Mechanism of blockage removing

After injecting into formation, the polymer is wrapped with the crude oil and inorganic scale. Under the condition of high temperature and high pressure, the blockage with complex structure and stable chemical property is formed as shown in Fig. 1. Here, a new blockage remover is developed with the function of permeation swelling, stripping desorption, oxidation degradation, low acid corrosion. This new blockage remover can remove the damage of the formation through a series of measures synergies.

(1) Cleaning of organic deposition

The cleaning agent can be used to remove the damage in the near wellbore area by stripping and dispersing the organic matter. Meanwhile, it can clean the oil film on the surface of rock, promote the change of wettability index, and improve the oil permeability.

(2) Degradation of polymer

Polymer is the main cause of plugging in polymer injection wells, so the effective degradation of polymer gel is the most important step [8]. According to the organic chemistry, the main blockage is a compound with a high stability in C-C backbone and it is difficult to degrade unless under high temperature and strong oxidant conditions. When the degradation agent contacts with the strong oxidizer molecular, the polymer is oxidized to produce free radicals (•OH), alpha and beta pyrolysis cracking reaction initiated by free radicals lead to the rupture of molecular main chain, ultimately the molecular weight of polymer decreased rapidly. Meanwhile, accompanied with the decarboxylation and deamination, different oxidative degradation products were produced, and the long chain of polymer was broken down and finally achieved the goal of polymer degradation. The degradation agent also has a certain bactericidal effect, it can kill the bacteria on the pipeline and near the wells so as to avoid the contact between the bacteria and polymer [9,10]. The reaction process is shown in Fig. 2.

In addition to the crude oil and polymer, there are still a large number of clay minerals and mechanical impurities in the reservoir. The acid solution is used to solve these problems.

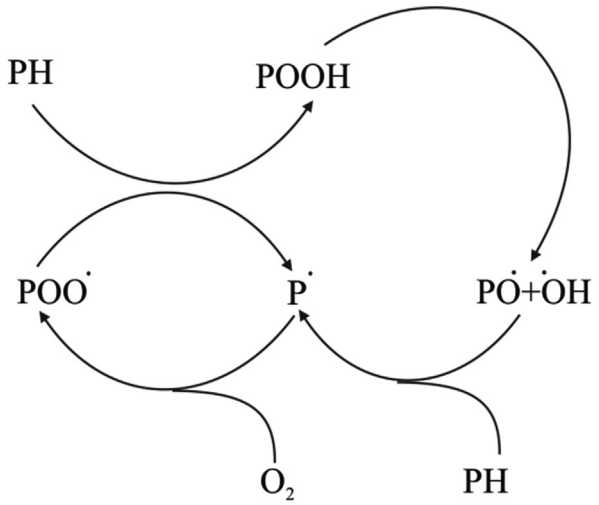

Fig. 2. Schematic diagram of oxidative degradation.

3. Experiment

3.1. Materials

AP-P4 (The hydrophobic associated polymers which are used in Bohai Oilfield, $M_w = 1000 \times 10^6$ g/mol, solid content is 88.02%); fluid used in test is the formation water whose salinity is 19,334 mg/L (The salinity of formation water in Bohai Oilfield is 1500–2000 mg/L) with main components shown in Table 1; the crude oil (viscosity is 2048 mPa s at 60 °C) and oil sands used in the test are both from Bohai Oilfield. The blockage sample is from SZ36-1 in Bohai Oilfield. The chemicals used in the experiment are shown in Table 2.

3.2. Apparatus

Forcing stirrer is used to prepare polymer solution; Brookfield

Table 1
Main components of stimulation formation water.

Medicament	$CaCl_2$	$MgCl_2 \cdot 6H_2O$	NaCl
Content(g/L)	5.7165	4.3150	87.2890

Fig. 1. Sample of blockage in Bohai Oilfield.

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