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The Research and Application of Adjustable Drive Improve Oil Recovery Technology in Ansai Low Permeable Fracture Reservoir

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Abstract

In order to solve the serious problem that the injected water channeling is serious and the water flooding effect is getting worse in Ansai low permeability fractured reservoir. Developed the gelling movable gel profile control displacement-agent RD which Can control the gel time and the strength. Select out the surfactant XSY-1 that can reduce water interfacial tension to ultra-low and can significantly improve oil displacement efficiency. Designed five group profiling experiments on parallel cores, optimized movable frozen rubber slug of surfactant slug best combination of 0.2 of the PV profile control agent add 0.40 PV surfactant, compared with the water flooding ways to enhance oil recovery of 22.5%. Adjustable drive combined with technology is the effective way to improve the Ansai low permeability fractured reservoir water flooding effect.

Keywords: Computer Vision Algorithm, Drone, Graphics and Image Processing, Real-time System

1. Introduction

A development block in Ansai Oilfield was discovered in 1983 and developed by water injection in 1990. The oil-bearing area is 79.44km2, the geological reserves are 5.4×108t, the average reservoir porosity is 13.7%, the average permeability is 4.3×10-3μm2, and the formation crude oil viscosity is 1.95 mPa. s, the reservoir temperature is 54.7°C, which is a low-permeability and low-yield fractured reservoir. As of December 2012, there were a total of 522 oil production wells and 265 water injection wells, with a cumulative oil production of 620.5×104t, a comprehensive water cut of 56.3%, and a production rate of 11.2%. After more than 20 years of water injection development, the "advantage channel" of water flooding has been formed, and the phenomenon of water channeling is very serious. There are "unblockable, short effective periods, unable to inject water after plugging, low oil washing efficiency, and poor lateral oil wells." Such problems have made the effect of water flooding development worse and worse in recent years.

In order to solve the above problems, an indoor research on the technology of profile control and flooding combined with enhanced oil recovery has been carried out, using movable jelly deep profile control technology to block natural fractures, artificial fractures, high permeability layers and other water flooding dominant channels. Re-use oil-displacing agent flooding technology, play the synergistic effect of profile control technology to expand the swept volume and oil-displacing agent flooding technology to improve oil washing efficiency, and greatly improve the waterflooding recovery rate of low-permeability and low yield fractured reservoirs [1-3].

Low permeable fracture reservoirs, also known as tight reservoirs, have become increasingly important in recent years due to the depletion of conventional reservoirs [4]. These reservoirs are characterized by low porosity and permeability, making it difficult to extract oil and gas. Ansai low permeable fracture reservoir, located in the Ordos Basin of China, is a representative of such reservoirs. The recovery rate of oil in these reservoirs is usually less than 10%, which is far from satisfactory [5]. Therefore, improving oil recovery from these reservoirs has become a significant challenge for the oil and gas industry.

One of the main methods to enhance oil recovery from low permeable fracture reservoirs is through the use of enhanced oil recovery (EOR) techniques. EOR techniques can increase the recovery rate of oil by changing the physical and chemical properties of the reservoir fluids, or by altering the reservoir pressure [6]. However, these techniques are often expensive and have limited success in tight reservoirs. Adjustable drive to improve oil recovery technology (ADIORT) is a new EOR technique that has shown promise in increasing oil recovery from low permeable fracture reservoirs. ADIORT uses a combination of waterflooding and polymer flooding to improve oil recovery [7]. Waterflooding is a primary recovery technique that involves injecting water into the reservoir to push oil towards the production wells. Polymer flooding is a secondary recovery technique that involves injecting a polymer solution into the reservoir to increase the viscosity of the water, and thus the ability of the water to sweep the oil [8].

The research and application of ADIORT in Ansai low permeable fracture reservoir has been the focus of several studies in recent years. This paper aims to provide an overview of the current state of research and application of ADIORT in Ansai low permeable fracture reservoirs, and to discuss the potential of ADIORT as a promising EOR technique for tight reservoirs [9]. Ansai low permeable fracture reservoir is located in the Ordos Basin of China, which is one of the most important oil and gas producing basins in China. The reservoir is a tight sandstone reservoir with low porosity and permeability. The recovery rate of oil in this reservoir is typically less than 10%, which is far from satisfactory [10]. The main challenge in recovering oil from Ansai low permeable fracture reservoir is the low permeability of the rock. The low permeability of the rock makes it difficult for the oil to flow through the pores, and thus difficult to extract. Additionally, the reservoir has a high water cut, which further reduces the amount of oil that can be recovered.

To overcome these challenges, various EOR techniques have been studied and applied in Ansai low permeable fracture reservoirs. However, most of these techniques have had limited success due to the unique characteristics of the reservoir. ADIORT is a new EOR technique that has shown promise in increasing oil recovery from low permeable fracture reservoirs. The technique is based on the combination of waterflooding and polymer flooding. Waterflooding is a primary recovery technique that involves injecting water into the reservoir to push oil towards the production wells. Polymer flooding is a secondary recovery technique that involves injecting a polymer solution into the reservoir to increase the viscosity of the water, and thus the ability of the water to sweep the oil.

2. Literature Review

Application of Adjustable Drive Improve Oil Recovery Technology in Ansai Low Permeable Fracture Reservoir

Enhanced oil recovery (EOR) techniques have been widely studied and applied in low permeable fracture reservoirs in recent years, in order to improve the recovery rate of oil. Adjustable drive to improve oil recovery technology (ADIORT) is a new EOR technique that has shown promise in increasing oil recovery from tight reservoirs. This literature review will provide a detailed analysis of the current state of research and application of ADIORT in Ansai low permeable fracture reservoir. [11] conducted a laboratory experiment to investigate the application of ADIORT in Ansai low permeable fracture reservoir. They used a core flooding method to simulate the waterflooding and polymer flooding processes, and found that the combination of waterflooding and polymer flooding improved oil recovery by increasing the viscosity of the water, and thus the ability of the water to sweep the oil. They also found that the polymer solution reduced the mobility ratio, which is the ratio of the mobility of the injected water to that of the oil. This reduction in mobility ratio increased the sweep efficiency of the waterflooding, and thus improved oil recovery. They also found that the optimal polymer concentration and injection rate were dependent on the specific characteristics of the reservoir, such as the permeability and porosity of the rock. The study concluded that ADIORT is a promising EOR technique for tight reservoirs, and that further research is needed to optimize the technology.

[12] also evaluated the performance of ADIORT in Ansai low permeable fracture reservoir. They used a numerical simulation method to evaluate the oil recovery under different polymer flooding conditions. The study found that the

polymer flooding improved oil recovery by reducing the mobility ratio and increasing the sweep efficiency of the waterflooding. They also found that the optimal polymer concentration and injection rate should be determined based on the specific characteristics of the reservoir. The study concluded that ADIORT is a useful EOR technique for low permeable fracture reservoirs, and that the optimal conditions should be determined through further research. [13] conducted a field trial to investigate the application of ADIORT in Ansai low permeable fracture reservoir. They found that the combination of waterflooding and polymer flooding significantly improved oil recovery compared to waterflooding alone. They also found that the optimal polymer concentration and injection rate were dependent on the specific characteristics of the reservoir, such as the permeability and porosity of the rock. The study concluded that ADIORT is a promising EOR technique for tight reservoirs, and that further research is needed to optimize the technology.

In summary, the literature suggests that ADIORT is a promising EOR technique for low permeable fracture reservoirs. The studies all indicate that the combination of waterflooding and polymer flooding improved oil recovery by increasing the viscosity of the water, reducing the mobility ratio and increasing the sweep efficiency. The studies also suggest that the optimal polymer concentration and injection rate should be determined based on the specific characteristics of the reservoir, such as permeability, porosity, and rock properties. However, all studies agree that further research is needed to optimize the technology and to have a more comprehensive understanding of the mechanism of ADIORT.

3. Research Method

3.1. Main reagents and material

The polymer is a high molecular compound formed by hydrolysis and copolymerization of acrylamide and vinyl cationic monomer under certain conditions. The relative molecular mass is 15 million, the surfactant XSY-1 is an anionic non-ionic sulfonate surfactant, and the crosslinking agent is a modified polymethylol phenolic cross-linking agent [14]. The above are all products of Bozhong Technology. The crude oil is the on-site crude oil in Ansai Oilfield, the interfacial tension is measured with dehydrated crude oil, and the simulated oil is configured with dehydrated crude oil and kerosene for oil displacement. The simulated oil viscosity is 2.0 mPa.s. The mixing water is the injection water on-site in Ansai Oilfield, and the ion composition of the injected water is shown in Table 1. The core is an artificial homogeneous core with a size of 4.5×4.5×30cm.

Table. 1. Composition of injected water ions in Ansai Oilfield

Cation(mg/L)			Anion(mg/L)			pH value	Total salinity (g/L)	Water type
Na++K +	Ca2+	Mg2+	Cl-	SO42-	HCO3-			
25685.5	4585.6	850.6	49358. 8	658.8	382.1	6.6	81.5	CaCl2

3.2. Experimental methods and procedures

The polymer and cross-linking agent are injected with water on-site in Ansai Oilfield to prepare movable jelly solutions of different concentrations, which are aged into glue in a 55°C thermostat, and their viscosity is measured regularly with an RV-2 rotary viscometer [15]. A series of oil-displacing agent solutions of different concentrations were prepared by injecting water on-site in Ansai Oilfield, adding dehydrated crude oil from Ansai Oilfield, and measuring the interfacial tension with a Texas-510 spinning drop interfacial tensiometer at 55°C and 4500 r/min.

In order to simulate the permeability difference of low-permeability reservoirs, two artificial cores with different permeability are selected: one has a permeability of 5×10-3um2, and the other has a permeability of 500×10-3um2, thus forming a parallel core assembly. Under the condition of the experimental temperature of 55 ℃, carry out the optimization experiment of the control and drive combination. At the beginning of the experiment, first drive the parallel core assembly water to a water content greater than 95%. Then, profile control agents with different pore volumes were injected into the high-permeability cores. After gelling at the experimental temperature, 0.4%

surfactant XSY-1 of 0.40 times the pore volume was injected, and finally water was flooded to a water content greater than 95%. According to the liquid production and oil production at each stage, the water cut and the recovery factor are calculated.

4. Experimental results and discussion

4.1. Screening of movable jelly formula

The on-site injection of Ansai Oilfield has a high content of calcium and magnesium ions, and it is difficult for ordinary anions to partially hydrolyze polyacrylamide [16-18]. Therefore, the crosslinked polymer jelly profile control agent is prepared by selecting a polymer formed by hydrolysis and copolymerization of acrylamide and vinyl cationic monomer. Under certain conditions, the influence of polymer concentration and cross-linking agent concentration on the performance of cross-linked polymer jelly profile control agent was studied, and the formula of cross-linked polymer jelly profile control agent used in the field was selected as: polymer concentration 1000-4000mg/L, cross-linking agent concentration 200-1000mg/L, cross-linked polymer jelly profile control agent reaction time can be controlled in the range of 30-180h, the strength of the formed jelly is between 2000-100000mPa·s. The polymer concentration and cross-linking agent concentration can be adjusted according to the application situation, and the reaction time and gel strength of the cross-linked polymer jelly profile control agent can be controlled.

4.2. Performance Evaluation of Surfactant XSY-1

Table 2 shows the relationship between the concentration of surfactant XSY-1 and the interfacial tension of oil and water. As the concentration of surfactant XSY-1 increases, the interfacial tension of oil and water decreases. When the concentration of surfactant XSY-1 increased from 0.5×103mg/L to 4.0×103mg/L, the oil-water interfacial tension dropped from 626×10-3 to the lowest value of 2.4×10-3mN/m; after that, the oil-water interfacial tension As the concentration of surfactant XSY-1 increases, it increases.

Table. 2. The relationship between the concentration of surfactant XSY-1 and interfacial tension

Concentration×103 (mg/L)	0.5	1.0	2.0	3.0	4.0	5.0	0.7	0.08
Interfacial tension×10-3 (mN/m)	626	76	46	6.5	2.4	5.2	7.6	5.3

Figure 1 shows the relationship between the oil-water interfacial tension and the measurement time when the concentration of the surfactant XSY-1 is 4.0×103 mg/L. It can be seen that the oil-water interfacial tension decreases rapidly with the increase of the measurement time. After the measurement time is extended to 10 minutes, the oil-water interfacial tension reaches the minimum value of 2.4×10-3 mN/m. After that, the oil-water interfacial tension is stable, that is, the dynamic interfacial tension and the equilibrium interface The tension value is basically the same. The surfactant XSY-1 solution has ultra-low interfacial tension and strong oil-washing ability, so it can be used as an oil-displacing agent.

4.3. In Experiments under Different Channel Environments

In Experiments under Different Channel Environments, the Success Rate of UAV Flying through the Channel is Shown in Table 1 and Figure 1.

Table. 3. Experimental results in different environments

Surroundings	Channel 1	Channel 2	Channel 3	Channel 4
Number of experiments	10	10	10	10
Success rate	90%	80%	90%	86,67%

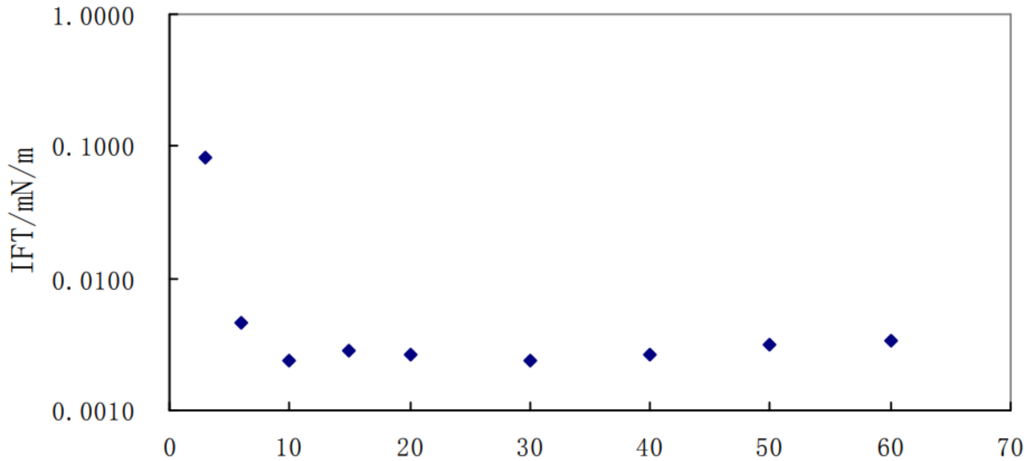

Fig. 1. The relationship between the interfacial tension of 0.4%XSY-1 and the measurement time

Table 3 lists the parallel model water flooding, oil-displacing agent flooding, and the combined flooding experiment results of movable gel slug and oil-displacing agent slug. From the table data, it can be seen that:

(1) The parallel core model is waterflooded under the condition of 100 times difference, and the waterflood recovery rate of the model is 43.6%, indicating that low permeability layers are difficult to produce; (2) The parallel model is used for oil displacement agent flooding, and the recovery rate is 47.8 %, which is 4.2% higher than the waterflooding recovery factor, indicating that the oil displacing agent only drives out the crude oil in the high-permeability layer, plays the role of oil washing, and does not expand the swept volume; (3) Use the profile control agent to Core plugging can reduce its fluid absorption and increase the fluid absorption of low-permeability cores. The larger the slug of the profile control agent, the stronger the plugging effect, which can give full play to the oil displacing agent to displace the crude oil in the low-permeability core. For example, when the profile control dose is 0.2PV, the recovery factor of the model is 66.1%, which is 22.5% higher than that of water flooding. The experimental results of the parallel core model show that for low permeability fractured reservoirs, the combination of profile control technology and oil displacement technology can greatly increase the recovery factor.

Table. 4. Experimental results in different environments

hashtag	Before measures			After the measures			Daily oil increase /t	Water cut rate /%
	Nissan fluid/m3	Nissan Oil/t	Water content/%	Nissan fluid/m3	Nissan Oil/t	Water content/%		
And 54-21	1.83	0.35	77.6	2.09	0.55	69.2	0.20	8.4
And 54-22	2.41	1.82	11	2.49	1.88	11	0.05	0
And 54-23	3.03	1.40	45.8	2.71	1.28	44.3	-0.12	1.5
And 55-21	1.76	0.25	83.6	4.95	1.47	65.3	1.22	18.3
And 55-23	8.22	0.00	100	2.35	0.35	82.3	0.35	17.3
And 56-21	5.82	1.91	61.3	4.35	1.16	68.7	-0.75	-7.4
And 56-22	0.89	0.60	20.9	2.68	1.06	53.6	0.46	-32.7
And 56-23	7.59	0.31	95.2	3.5	1.01	66.4	0.7	28.8
Total	31.6	6.64	77.8	25.12	8.76	59.2	2.12	18.6

The Baiyushan oil area of Ansai Oilfield is a typical low-permeability fractured reservoir. The fractures are multi-directional and irregular, with strong reservoir heterogeneity and poor physical properties [19,20]. After being put into water injection development, the water cut rises quickly, and the water injection development effect Poor, mainly manifested in: (1) The water absorption condition becomes worse, the production of water flooding reserves is low, (2) The injected water flows ineffectively along the fracture direction, and the water flooded oil wells increase. In order to solve the problems existing in the water injection development of the block, in May 2015, the wells 55-22 were screened in the area, and field tests were carried out to improve the oil recovery by the control and flooding assembly. The cumulative injection of gel profile control agent was 1500m3, The oil agent is 2000 m3, the well group corresponds to eight oil wells, and six oil wells have seen different degrees of oil increase and precipitation effects (shown in Table 4). Without considering the comprehensive decline in oilfield production, the daily oil production of the well group is determined by measures. The previous 6.64t increased to 8.76t after the measure, an increase of 2.12t; the comprehensive water cut decreased from 77.8% before the measure to 59.2%, a decrease of 18.6%. The field test results show that the area is suitable for profile control and flooding to increase recovery technology.

(1) According to the conditions of Ansai low-permeability fractured reservoirs, a movable jelly system that can adjust the gel time and gel strength is developed, reducing the oil-water interfacial tension to an ultra-low level. At the same time, the oil displacement efficiency of the oil displacement agent can be greatly improved. (2) The combined injection of movable gel profile control agent slug and oil displacing agent slug is better than the use of a single system. The use of the combination of 0.2 PV profile control agent+0.40 PV oil displacement agent can increase oil recovery by 21.4% compared with water flooding. (3) The field test results show that the combination of profile control and flooding combined with enhanced oil recovery technology is an effective way to improve the recovery of Ansai low-permeability fractured reservoir by water flooding.

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5. Conclusion

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