Performance evaluation and application of a new phase permeability improver system

Changjun Long^{1*}, Jie Xiao ², Bin Zhang¹, Ning Li ¹, Shuzhi Xiu ¹

¹Engineering Technology Research Institute of Huabei Oil Company, Renqiu city, Hebei province, 062550, China

²Exploration and Development Research institute of HuaBei Oilfield Company, Renqiu city, Hebei province, 062550, China

Abstract. A novel hydrophobically associating polymer (HHA-RPM) was synthesized by a solution polymerization method with a modified acrylamide (AM) as the main component and implanting an anionic group. The static adsorptivity of the polymer was measured by an ultraviolet visible light photometer with an adsorption amount of about 11.0 mg/g. The influence of concentration, temperature and salinity on the apparent viscosity of the polymer solution system was investigated indoors, and the HHA-RPM system was prepared. In view of the on-site requirements for the timeliness of the phase permeability improver, an antioxidant was added to the system to evaluate the durability of the HHA-RPM system.

1 Introduction

Low permeability reservoirs are characterized by low porosity, low permeability, large specific surface area and fracture development. In the relative permeability curve of oil and water, the two-phase total area is very small, which makes the development difficult. Low permeability reservoirs occupy a large proportion in the blocks of China's oil fields, and most oil Wells are developed by water injection.^[1] The problem is that the rate of water production rises too quickly, so the Wells go into a high water cut in a very short time. Water controlled fracturing technology is an important measure to stabilize oil production in oilfield. ^[2-3] Phase permeability improver is a key technology to determine the success or failure of water controlled fracturing.^[4]

The article gets a main agent of permeability to improve agent, and has been developed suitable for hebei central block permeability to improve agent system.

2 Synthetic part

2.1 experimental drugs and instruments

Experimental drug: self-made polyacrylamide (HPAM), analytically pure, hydrolysis degree 18.3%; Crosslinking agent: aluminium citrate, industrial product; NaCl, KCl, CaCl₂, CH₃COONa•3H₂O, Al₂(SO₄)₃•18H₂O, acetic acid, sodium formate, cadmium iodide. Artificial core.

Test instruments: model 752 uv-visible spectrophotometer, digital display intelligent magnetic agitator, constant temperature water bath, electronic

balance, HAAKE MARSIII rheometer, RV2 rotational viscometer, high temperature and high pressure dynamic filtration meter.

2.2 synthesis of phase permeability improver

Acrylamide, acrylic acid, AMPS and hexadecyl trimethylallyl ammonium chloride were dissolved in deionized water and oxygenated with nitrogen for 30min. At the same time, the reducing agent and oxidant were added to keep the temperature below 45°C. After the dripping, the gel substance was obtained by the reaction at 45°C for 2h. Take the gel out, cut it into small pieces, dry it, grind it, and get the polymer

3Test results and analysis

3.1 Adsorption

The concentration of copolymer solution is one of the key factors affecting the static adsorption capacity [6]. With reference to sy-t5862-1993 determination of properties of acrylamide polymers for oil displacement, the adsorption isotherm of the polymer at 60-130 mesh pure quartz sand was determined by using different polymer concentrations, in which the copolymer adsorption time was 24h, and the ratio of copolymer solution to quartz sand was 10mL/g. Then, the static adsorption of the polymer under different conditions was converted.

*Corresponding author's e-mail: cyy_lcj@petrochina.com.cn

Figure 1. Adsorption isotherm of polymer on quartz sand

The adsorption isotherm of HHA-RPM was L-shaped, which was basically consistent with Langmuir adsorption. When the equilibrium concentration of the copolymer was about 5000mg/L, the adsorption reached the saturation state, and the adsorption hardly increased. The optimal adsorption capacity is about 11mg/g.

3.2 Cross ratio

1000ml 0.5% HHA-RPM solution was prepared and poured into 8 beakers, 100ml each. Add 0.1ml, 0.2ml, 0.3ml, 0.4ml, 0.5ml, 0.7ml, 0.9ml and 1mL respectively, seal and stand for several hours. At room temperature, rv2-type rotational viscometer was used every 2h to test the viscosity of the solution, and the statistical results were shown in table 1.

Table 1. Influence of crosslinking agent on the time of glue formation and apparent viscosity

Project	Crosslinking agent dosage %							
	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.0
Crosslinking time /h	36	30	28	24	22	20	14	16
Apparent viscosity /mPa•s	120	185	230	378	494	559	582	654

There is a close relationship between the amount of crosslinking agent and the gel forming time. As the amount of crosslinking agent increases, the crosslinking time will decrease. This is because in the solution, with the increase of the amount of crosslinking agent, the concentration of crosslinking agent increases, the probability of encountering the polymer molecular chain increases, and the crosslinking opportunity increases. In addition, since it takes a certain time to prepare the solution on site and inject into the formation, the shorter the crosslinking time is, the better. Therefore, the amount of solution crosslinking agent is chosen to be 0.3% and

the crosslinking time is 28h.

3.3 Temperature resistance

400ml of 0.5% HHA -RPM+0.3% JLJ-1 solution was prepared, and poured into 5 beakers, 80ml each, sealed and stood for 28h. At 80°C, 90°C, 100°C, 110°C, 120°C and 130 °C, the HAAKE MARSIII rheometer was used to test its apparent viscosity values respectively, and the shear rate was set at 170r/s. The results are shown in figure 2.

Figure2. Relationship between temperature and apparent viscosity

With the increase of temperature, the apparent viscosity of phase permeability improver increases first and then decreases. When the temperature is 90°C, the apparent viscosity reaches the maximum value, about 62mPa•s. This indicates that under 90°C, with the increase of temperature, the degree of cross-linking between polymer molecules is strengthened. Between 90°C and 120°C, the apparent viscosity showed a decreasing trend, indicating that the degree of crosslinking was weakened. However, from 120°C to 130°C, a sharp drop occurred, indicating that at this time, the polymer molecular chain connected by metal ion bond formed by aluminum citrate as the crosslinking agent was broken on a large scale, resulting in a sudden drop in viscosity.

3.4 Salt resistance

0.5% HHA-RPM+0.3% JLJ-1 +0.3%pH regulator (dilute 10 times acetic acid) solution 1000ml each; Take 7 beakers and mark them. Pour 100ml of the prepared solution into each beaker; Add 0.1g, 0.3g, 0.5g, 0.7g, 0.8g, 0.9g and 1.0g NaCl successively in the no. 1-7 beaker. Stir well with a magnetic mixer until dissolved evenly. After that, it was set aside for 90 minutes. The rheometer of HAAKE MARSIII was set at 90°C and 170r/s to test its viscose-temperature curve.

Figure3. The influence of salinity on the gluing degree of the system.

The apparent viscosity of phase permeability improver system is 55mPa•s, 40mPa•s, 33mPa•s and 22mPa•s, respectively, when the salinity is 0.3%, 0.5%, 0.7% and 1%. Obviously, it can be concluded that the apparent viscosity of the system decreases with the increase of salinity. And the system is in a stable state, still maintain a certain viscosity, indicating that the system has a good salt tolerance.

3.5 Timeliness

To ensure the long-term effectiveness of the cross-linked polymer system under stratigraphic conditions, oxygen in the solution needs to be removed, and antioxidants are

usually added to the system. The effect of stabilizer on the apparent viscosity of the system was investigated in this experiment.

In a constant temperature box at 90°C, the apparent viscosity of the phase permeability improver system decreased with the extension of time. At the shear rate of 6r/s, the apparent viscosity decreased from 680mPa•s to 480mPa•s, and the viscosity loss rate was 29.4%. After 80 days, the apparent viscosity tends to be stable and can be maintained at about 450mPa•s. The addition of stabilizer can eliminate the excess oxygen in the system and prevent the metal ions in the system from being oxidized. The addition of stabilizer ensures the stability and high efficiency of the system.

Figure 4. Viscosity curve of the system under test with time.

4 Conclusions

Through the performance evaluation and field test of the new phase permeation improver, the following conclusions are obtained.

(1) The phase permeability improver system suitable for Jizhong block of Huabei oilfield was determined. The optimized formula of the system was: 0.5% HHA-RPM+0.3% JLJ-1 (aluminum citrate) +0.3%pH regulator (acetic acid diluted 10 times) +0.05% stabilizer (antioxidant).

(2) The phase permeability improver system has stable performance and is easy to control: at the shear rate of 170r/s at the temperature of 90°C, the apparent viscosity value is 62mpa.s; The salinity (NaCl) content was 10000mg/L, the temperature was 90°C, and the apparent viscosity remained above 20mpa.s at 170r/s shear rate.

Acknowledgments

This work is funded by a major science and technology project of China national petroleum corporation, entitled “research and application of key technologies for the exploration and development of sustained and effective stable production in Huabei oilfield” (No:2017E-1505-3)

References

1. Li ruishan, Tang yinming, Fang qiuzhen, et al. Study on seepage characteristics of colloidal dispersion gel [J]. Jiangnan petroleum technology, 2003, 13(1): 22-24.
2. R.S. Sieright. Impact of permeability and lithology on gel performance[J]. SPE2410.
3. Liu Jianxin, Zhang Yinghua, Ren Shaoran. Laboratory Study on New Relative Permeability Modifier for Water Control[J]. Journal of Oil and Gas Technology, 2008, 30(5): 141-142.
4. Feng yujun, Luo chuanqiu, Luo pingya, et al. Study on characterization of microstructure of hydrophobically associating water-soluble polymer in aqueous media by scanning electron microscopy and environmental scanning electron microscopy [J]. Acta Petrolei Sinica, 2001, 17(6): 39-43.