Influence of Boron Content on Characteristics of Fracturing Fluid

Xin-jian CHEN\textsuperscript{1}, Ding-yu KANG\textsuperscript{1}, Jia-jia DU\textsuperscript{1}, Sheng-wei SHI\textsuperscript{1}, Cheng-tun QU\textsuperscript{1,2,*}, Tao YU\textsuperscript{1,2} and Yan LI\textsuperscript{1,2}

\textsuperscript{1}College of Chemistry and Chemical Engineering, Xi’an Shiyou University, Xi’an 710065, P.R. China
\textsuperscript{2}State Key Laboratory of Petrochemical Pollution Control and Treatment, Beijing 102206, P.R. China

*Corresponding author

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Abstract. At present, fracturing is an important measure for oil and gas fields to increase production and increase profits; returned liquid generated after operation has become one of the important control pollutants for the environmental protection of oil and gas fields; re-use of fracturing fluid backwaters has become an important development direction of waste water resource utilization. In this paper, four kinds of different salinity aqueous solutions of distilled water, tap water, No.2 and treated backflow were studied; effect of different boron content on viscosity, temperature resistance and temperature-resisting shear resistance of fracturing fluid based on four kinds of water solvents. The results show that when the content of boron in distilled water is 1mg/L and the content of boron in tap water is 2mg/L, the viscosity, temperature resistance, shear resistance and temperature resistance of the fracturing fluid are all meet the requirements. No.2 simulated water and fracturing flow back fluid after treatment were added boron content of 10mg/L and 18mg/L respectively, the viscosity of the base fluid to meet the requirements, however, without boron, the shear resistance and temperature resistance are poor, does not meet the requirements.

Introduction

In the field of fracturing operations will continue to produce a large number of return waste water\textsuperscript{[1]}, back to the fluid after efficient gel breaking, flocculation, boron removal and removal of some metal ions, reconstituted guar fracturing fluid to meet the "general technical requirements of fracturing fluid" requirements\textsuperscript{[2]}, which is the key to the reuse of fracturing effluent. As the fracturing back row contains a higher concentration of boron, boron in water environment mainly in the form of boric acid, more difficult to use conventional methods to remove\textsuperscript{[3, 4]}. Therefore, it is necessary to determine the content of boron during the re-utilization of fracturing fluid after treatment; it is of great significance to reduce the processing cost of fracturing return fluid and improve the processing efficiency.

This paper mainly studies the influence of boron content in distilled water, tap water, No.2 simulated water and back-flow after treatment on the viscosity, temperature resistance and shear resistance, influence of boron content on characteristics of fracturing fluid under different salinities, it is concluded that the influence law of the thickener polymer in the fracturing fluid is affected by the concentration of different boron and the different salinity; for the treatment of drainage reuse technology research and provide experimental basis for the return\textsuperscript{[5]}.

Experimental Part

Materials and Instruments

Hydroxypropyl guar gum (HPG), Industrial grade; borax, sodium bicarbonate, sodium sulfate, magnesium chloride, calcium chloride, sodium chloride, potassium chloride, sodium hydroxide, analytical purity.
Haake RV30 Hack rotational viscometer (Huck company, Germany). ZNN-D6 Six-speed rotary viscometer, Qingdao Heng TEDA Mechanical and Electrical Equipment Co., Ltd. Complex fluid flow tester, United States.

**Experiment Method**

Take distilled water, tap water, No.2 simulated water and fracturing flowback fluid after treatment as a solvent, respectively, adding different concentrations of boron content, to the above solution was added hydroxypropyl guar at a concentration of 0.4% to prepare a fracturing fluid base fluid. pH adjustment using sodium hydroxide. 0.8% borax solution was prepared as a cross-linking agent[6].

**Viscosity Test**

Take the prepared fracturing fluid base fluid 350ml, viscosity was measured using a ZNN-D6 six-speed rotational viscometer.

Test conditions and methods: storage of 4h at 30℃ in constant temperature water bath, determination of viscosity under 100r/min with a ZNN-D6 six speed rotary viscometer[7].

**Temperature Capability Test**

To the prepared base fluid is added a crosslinking agent, formation of gelatin, test the temperature resistance using a complex fluid flow tester.

Test conditions and methods: the increase of temperature under the shear rate of 170s⁻¹, the temperature range is from 30℃ to 100℃; the time is 90min; When the apparent viscosity of fracturing fluid drops to 50mpa·s, the corresponding temperature is the highest temperature.

**Test of Resistance to Temperature and Shear**

Test conditions and methods: the shear rate is 170s⁻¹; the temperature is 60℃, shear time 60min, using the Haake RV30 Hack rotational viscometer test.

**Results and Discussion**

Tap water, No.2 simulated water and back flow ion content after treatment. Tap water and fracturing flowback fluid after treatment to the sampling for partial ion measurement and No.2 simulated water ions in Table 1.

Table 1. Tap water, No.2 simulated water, fracturing flowback fluid after treatment to the conventional analytical ion table.

<table>
<thead>
<tr>
<th>classification</th>
<th>tap water</th>
<th>No.2 simulated water</th>
<th>fracturing flowback fluid after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ρ(Cl⁻)/(mg·L)</td>
<td>19.99</td>
<td>13475.82</td>
<td>4283.67</td>
</tr>
<tr>
<td>ρ(CO₃²⁻)/(mg·L)</td>
<td>0.00</td>
<td>0.00</td>
<td>31.88</td>
</tr>
<tr>
<td>ρ(SO₄²⁻)/(mg·L)</td>
<td>9.05</td>
<td>200.85</td>
<td>566.32</td>
</tr>
<tr>
<td>ρ(Na⁺)/(mg·L)</td>
<td>4.21</td>
<td>7408.01</td>
<td>2062.78</td>
</tr>
<tr>
<td>ρ(Mg²⁺)/(mg·L)</td>
<td>4.57</td>
<td>179.89</td>
<td>51.05</td>
</tr>
<tr>
<td>ρ(Ca²⁺)/(mg·L)</td>
<td>28.06</td>
<td>1038.07</td>
<td>892.98</td>
</tr>
<tr>
<td>ρ(HCO₃⁻)/(mg·L)</td>
<td>66.11</td>
<td>172.69</td>
<td>249.80</td>
</tr>
</tbody>
</table>

Analysis of tap water and fracturing flowback fluid after treatment ion content in accordance with the "oil field water analysis method" SY / T 5523-2006 provisions of the determination.

**Influence of Boron Content on Characteristics of Fracturing Fluid under Different Solvents**

**Effect of Boron Content on Viscosity of Base Fluid of Fracturing Fluid under Different Solvents**

(1) Effect of boron content on the viscosity of base fluid under different salinities

Boron by different concentrations of borax by adding distilled water, tap water, No.2
simulation water and fracturing flowback fluid after treatment into the solution; preparation of hydroxypropyl guar gum base solution, the viscosity was measured separately. figure 1.

![Figure 1](image)

**Figure 1. Effect of Boron Concentration on the Viscosity of Base Fluid at Different Salinities.**

As can be seen from figure 1, use distilled water and tap water as solvent, with the increase of boron concentration, the viscosity of the base liquid changes significantly. With 1-2mg/L boron, the viscosity of the base liquid falls below 10mPa·s. No.2 simulated water and fracturing flowback fluid after treatment as a solvent. No.2 simulated water and fracturing flowback fluid after treatment significantly than distilled water and tap water to prevent the boron base fluid viscosity; boron concentration can be increased to 7mg/L and 18mg/L. It can be seen from the figure that when the salinity is low, the boron content has a great influence on the viscosity of the base fluid; When the degree of salinity is high, the boron content has little effect on the viscosity of the base fluid.

According to the petroleum industry standard SY / T6376-2008 "general technical conditions of fracturing fluid"[8], base fluid viscosity down to 10mPa·s or less, does not meet the standards. According to experiments, distilled water pH=7, boron concentration of 1mg/L; Tap water pH = 8.43, boron concentration 2mg/L; the No.2 simulated water pH was 7.34 and the boron concentration was 10 mg/L. The fracturing flowback fluid after treatment pH = 7.64, boron concentration of 18mg/L, exceed all not accord with.

Containing borate in aqueous solution can affect the degree of swelling of guar in water, thus affecting the viscosity of the base fluid. The experimental data analysis shows that the greater the initial concentration of borate in aqueous solution, the greater the degree of influence of the base fluid viscosity; In different degrees of salinity, more than a certain value, the base fluid viscosity significantly reduced, very obvious. This is because guanidine gum is less than fully swollen in water, guanidine gum molecules have not yet fully extended in water; borax added to the aqueous solution has been cross-linked with guanidine gum to form a relatively small molecular weight and volume colloidal morphology; as a result, the viscosity of the fluid in the fracturing fluid becomes smaller, even stratified, and cannot be crosslinked [9].

(2)Effect of boron concentration on temperature and shearing resistance of fracturing fluid under different solvents

Prepare the fracturing fluid according to the test method and increase the boron concentration in different solvents to make a solution, preparation of different concentrations of boron concentration of the fracturing fluid salinity; the evaluation method of fracturing fluid on the evaluation of the anti temperature and shear resistance of the prepared fracturing fluid, test results shown in Figure 2, Figure 3, Figure 4, Figure 5.

![Figure 2](image)

**Figure 2. Effect of boron in distilled water on the anti-temperature anti-shear ability of fracturing fluid.**

![Figure 3](image)

**Figure 3. Effect of boron in tap water on the anti-temperature anti-shear ability of fracturing fluid.**

282
Figure 2, Figure 3, Figure 4 and Figure 5 show the boron concentration in different solvents, fracture fluid temperature and shear resistance. Compared with clean water blank test, boron concentration in distilled water and tap water in the test, the fracture fluid temperature shear resistance less affected [6]. No.2 simulated water and treated back to the liquid temperature resistance to shear very poor, does not meet the standard.

No.2 simulated water and treated return fluid salinity, use salt water to prepare Jelly glue, the reaction of inorganic salts to water molecules will intensify, therefore, the resistance to temperature and shear resistance is obviously weaker than that of the adhesive when it is used in fresh water [10].

When the degree of mineralization inside the solvent is not high, boron concentration has a great impact; when the degree of salinity is high, the interaction between other ions affects the nature of the fracture fluid. From experimental analysis, the degree of mineralization is increasing, and the crosslinking rate of the prepared base liquid is much less than that of fresh water. the speed of cross-linking decreased gradually. Because the cross-linking agent relies on boric acid hydration [11], the presence of a large amount of inorganic salt may cause salting out effect of the polymer [12], resulting in the formation of network-type polymer chains more difficult, the speed of the cross-linking agent boron to hydroxyl boron is obviously reduced; and because HPG crosslinking depends on the presence of hydroxyborane, therefore, the increase in the degree of salinity in the system can cause polymer stretch blocked, retardation of cross-linking process in HPG system [5].

(3) Effect of Boron Concentration on Temperature Resistance of Fracturing Fluid under Different Solvents

Fracture fluid temperature resistance determines the depth of the formation; therefore, it is necessary to evaluate its temperature resistance. In order to investigate the performance of the fracture fluid prepared with different solvents containing boron in terms of temperature resistance, using different concentrations of boron in different solvents formulated fracturing fluid.

The effect of different boron concentrations in distilled water on temperature resistance is shown in Figure 6 and From Figure 6 can be seen, containing 1mg/L boron distilled water temperature temperature 92.12°C, compared with the blank control, temperature-resistant temperature decreases; temperature resistance worsened.

Figure 6. Effect of Boron on the temperature resistance of fracturing fluid in distilled water.

Figure 7. Effect of Boron on the temperature resistance of fracturing fluid in tap water.
The effect of different boron concentrations in tap water on temperature resistance is shown in Figure 7. As can be seen from Figure 7, within the test conditions, boron in water has little effect on temperature resistance. Temperature temperature is basically the same. The effects of different concentrations of boron on the temperature resistance of No.2 simulated water are shown in Figure 8. Can be seen from Figure 8, the temperature is below 60°C, compared with distilled water and tap water preparation fracturing fluid temperature resistance, the temperature is not high temperature, poor performance. The fracturing flowback fluid after treatment temperature resistance compared to the No.2 simulated water, the performance worse. The effect of different boron concentrations on the temperature resistance after treatment is shown in Figure 9.

No.2 simulated water and fracturing flowback fluid after treatment contains high Ga^{2+} and Mg^{2+}; as Ga^{2+} and borax cross-linking agent in the reaction of tetrahydroxy boron to generate insoluble calcium borate; affect guar gum cross-linking, thereby weakening the temperature resistance of fracturing fluid. The adverse effects of different kinds of inorganic salt ions on the characteristics of fracturing fluids have the greatest impact with Ga^{2+} and Mg^{2+}; the temperature of the fracturing fluid have a greater impact[5].

Summary

(1) When the salinization degree is low, the content of boron has a significant effect on the viscosity, temperature resistance and shear resistance and temperature resistance of the fracturing fluid, need to deal with its boron content or masking.

(2) Back to the liquid after treatment cannot be used directly for the preparation of fracturing fluid, which needs to reduce the degree of salinity, mainly Ga^{2+} and Mg^{2+}, the fracturing fluid can be prepared again.

(3) Reduce the degree of mineralization in the solvent, the need to limit the boron content can be formulated into a high-performance fracturing fluid.

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References


