

# Research and Application of Super Low Concentration Guar Gum Fracturing Fluid System in Coalbed Methane Wells

Liu Yuting<sup>1</sup>, Liang Li<sup>1</sup>, Liu Ping<sup>1</sup>, Guan Baoshan<sup>1</sup>, and Jiang Wei<sup>1</sup>

<sup>1</sup>Fracturing & Acidizing Technical Service Center, RIPED-Lanfang, PetroChina, China

## Abstract

Super low concentration guar gum gel fracturing fluid has the advantages of width generation capacity and proppant carrying capacity, low thickener, less solid residue after gel breaking in low temperature, small damage to the reservoir, small friction in the fracturing process, and substantial low cost, with optimistic application prospect. Field application in coalbed methane wells at Hancheng and Jincheng achieved good effect.

### 1. Long chain mutipolarity-headed crosslinking agent

To guarantee excellent width generation capacity and proppant carrying capacity of fracturing fluid, as far as possible to reduce the filter cake thickness and the thickener usage, to take advantage of crosslinked gel fracturing fluid system performance, the best way is to reduce the usage of thickener. But with the decreasing concentration of guar gum, the hydroxyl points on cross linking of guar gum molecular chain is decreased, and the crosslinked gel has poor crosslinking, condition with conventional crosslinking agent because thickener concentration is to low to cross.

For this purpose, researched and developed the long chain mutipolarity-headed crosslinking agent. The crosslinking agent is formed by inorganic boron, long chain organic alcohols through reaction separation, purification under certain conditions. The crosslinking agent has mutipolarity characteristic, and forms a three-dimensional network structure with the molecular junction of the guar gum molecular. The crosslinking agent improves the efficiency of crosslinking, and achieves the goal of reducing thickener concentration.

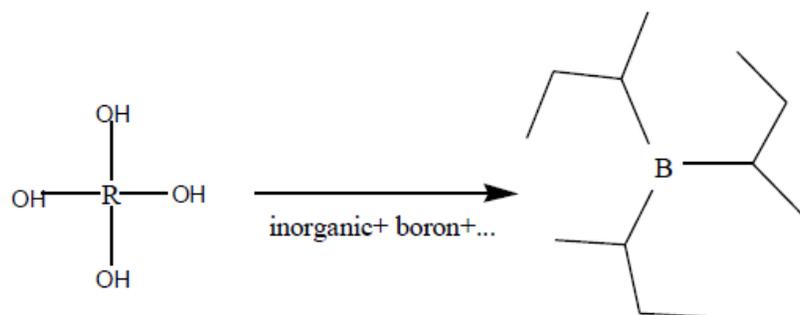


Fig. 1. Crosslinking agent synthetic map.

## 2. The super low concentration guar gum fracturing fluid system performance evaluation

Super low concentration guar gum fracturing fluid system performance evaluation is reference to oil and gas industry standards SY/T5107-2005. According to the reservoir conditions optimized three sets of fracturing fluid formulas, respectively, and evaluated the performance. The basic formulas are as follows:

1# : 0.10% hydroxypropyl guar gum+0.30% cleanup additive-FACM-41 +0.25% crosslinking agent-GB-1

2# : 0.12% hydroxypropyl guar gum+0.30% cleanup additive-FACM-41 +0.30% crosslinking agent-GB-1

3# : 0.15% hydroxypropyl guar gum+0.30% cleanup additive-FACM-41 +0.30% crosslinking agent-GB-1

### *2.1 Performance measurement of base fluid apparent viscosity, crosslinking time, etc.*

When the thickener concentration is low, faced two problems, one is the state of crosslinked gel, the other is the crosslinking time is too long to lead wellbore sand setting, and to affect the construction. Due to the nature of the crosslinking agent has mutipolarity-head, long chain mutipolarity-headed crosslinking agent leads to a rapid cross-linking time under the low concentration, and satisfied the requirements.

| Formula | Concentration (%) | pH  | Apparent viscosity (mPa.s) | Crosslinking ratio (%) | Crosslinking time (s) |
|---------|-------------------|-----|----------------------------|------------------------|-----------------------|
| 1#      | 0.10              | 7.0 | 6.0                        | 0.25                   | 15-30                 |
| 2#      | 0.12              | 7.0 | 7.5                        | 0.30                   | 10-20                 |
| 3#      | 0.15              | 7.0 | 9.0                        | 0.30                   | 10-20                 |

**Table 1. Performance measurement of base fluid apparent viscosity etc.**

### *2.2 Gel breaking experiment*

Super low concentration guar gum fracturing fluid has different crosslinking mechanism with general guar gum fracturing fluid. There are differences between gel breaking mechanism also; ammonium persulfate can break gel well at low temperature.

### *2.3 The measurement of residue and gel breaking liquid surface tension*

Gel breaking liquid surface tension is less than 30mN/m. This is help flowback fluid's flowback, and reduced the harm of coal and rock reservoir. Residue content is lower more than double than conventional fracturing fluid gel breaking liquid residue (200~300 mg/L), it can greatly reduce the plugging of fracture flow capacity, improve the single well production. The experiment results are shown in Table 2.

| Formula | Concentration (%) | Residue content (mg/L) | Average residue content (mg/L) | Surface tension (mN/m) |
|---------|-------------------|------------------------|--------------------------------|------------------------|
| 1#      | 0.10              | 67.0                   | 66.0                           | 27.84                  |
|         |                   | 65.0                   |                                |                        |
| 2#      | 0.12              | 80.0                   | 78.5                           | 28.01                  |
|         |                   | 77.0                   |                                |                        |
| 3#      | 0.15              | 95.2                   | 94.0                           | 27.22                  |
|         |                   | 92.7                   |                                |                        |

**Table 2. Gel breaking liquid residue content and surface tension measurement.**

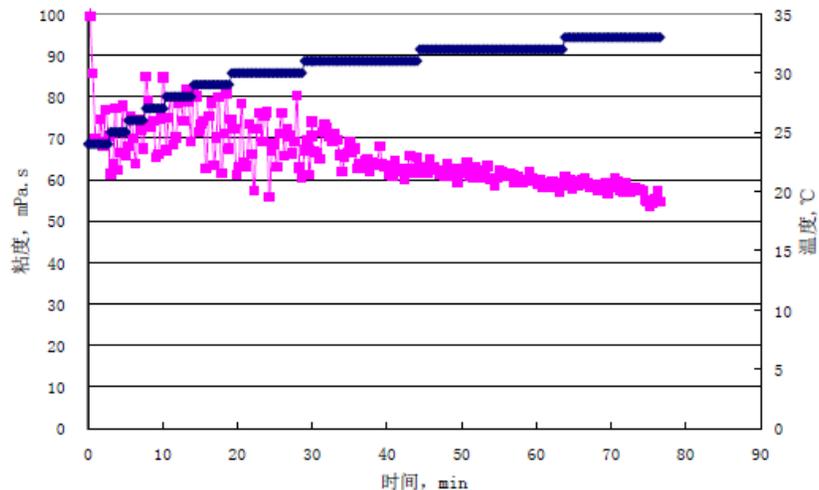
#### *2.4 The rheological experiment*

Rheometer has a big error in low viscosity liquid measuring, so use six-speed viscometer to measure the above three formulas at 30°C, the results are Table 3.

| Formula | Thickener concentration (%) | Viscometer speed (rpm) | Viscosity (mPa.s) |
|---------|-----------------------------|------------------------|-------------------|
| 1#      | 0.1                         | 100                    | 7.5               |
| 2#      | 0.12                        | 100                    | 18.0              |
| 3#      | 0.15                        | 100                    | 75.0              |

**Table 3. Viscosity of the crosslinking gel with different thickener concentration.**

Gel of 3# formula conducts rheological experiment using rheometer, the results shown in Figure 2.



**Fig. 2. 3# formula rheological experiments.**

The data in Table 3 shows that viscosity base fluid conforms to the requirements of the construction. Rheological experiments show that the fracturing fluid viscosity data is greater than 50 mPa.s at the end of the experiment. Gel can guarantee the construction smoothly.

### 2.5 Damage experiment

Push coal dust into coal core column. Use fracturing fluid damage tester for gel breaking liquid damage experiment. Two formulas' damage rates are relatively low, less than 30%, the results are in Table 4.

| Formula | Thickener concentration (%) | Permeability before damage ( $\times 10^{-3} \mu\text{m}^2$ ) | Permeability after damage ( $\times 10^{-3} \mu\text{m}^2$ ) | Damage rate (%) |
|---------|-----------------------------|---|--|-----------------|
| 1#      | 0.1                         | 0.7147  | 0.5797   | 18.89           |
| 3#      | 0.15                        | 0.6665  | 0.5078   | 23.81           |

**Table 4. Damage experimental results.**

### 3. The field application: classic well example

The fracturing fluid system is used in Huabei oilfield of China, which contains Jincheng coal bed methane company's four wells and Changzhi coalbed methane company's three wells, and construction success rate is 100%, and fully complies with the design. 3# coal seam of AN1-50 block's electric log interpretation porosity is 4.3%, the air content is  $17.46\text{m}^3/\text{t}$  to  $26.33\text{m}^3/\text{t}$ , coal seam top is 12m to 17m thick sandy mudstone, coal seat is 12m to 15m thick sandy mudstone, aquosity is weak, poor is permeability poor, has isolated coal seam interval.

Net cumulative injection fluid volume is  $413.2\text{m}^3$ , fluid volume is  $391.8\text{m}^3$ , sand volume is  $50.2\text{m}^3$ , delivery capacity is  $3.8\text{m}^3/\text{min}$ , and the average sand ratio is 23%. When the pressure is 44.08MPa, Formation is breakdown, and fractures are stretched with 30MPa extension pressure after the fractures extend. Pad fluid stage joins 30kg ammonium persulfate gel breaker. Carrying fluid phase joins 45kg ammonium persulfate gel breaker. Displacement fluid stage joins ammonium persulfate gel breaker 75 kg. The whole construction process joins average gel breaker amount is 0.025ppm. Flowback fluid shows fracturing fluid gel is good breaking.