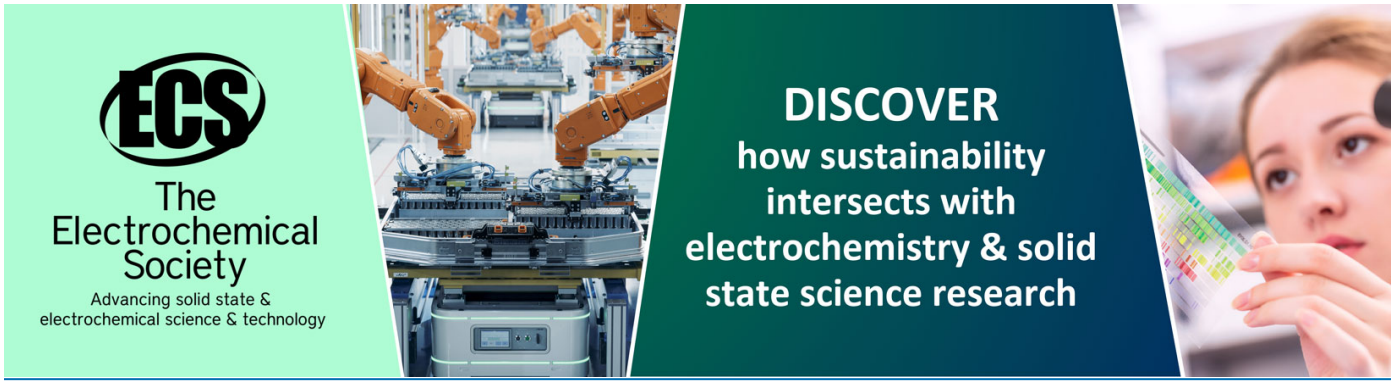
A new fracturing material in oil and gas industry



IOP Conf. Series: Materials Science and Engineering **220** (2017) 012011 doi:10.1088/1757-899X/220/1/012011

A new fracturing material in oil and gas industry

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Abstract. In this study, a novel non-residual fracturing fluid was developed. This fracturing fluid system is crosslinked under acid condition and owns the advantages of fast dissolving, excellent sand carrying ability, non-residual, good anti-swelling property and low damage etc. Experimental results show that this system viscosity can reach 95% of peak viscosity in 3 minutes, the surface tension of the gel breaking liquid is 25 mN/m ,the residue content of the gel breaking fluid is 10mg/L, core permeability damage rate less than 15% which greatly reduces the damage to formation and fracture conductivity. The shear viscosity of fracturing fluid for 90min is 260 mPa.s, it has good resistance to high temperature and shearing performance and can meet the requirements of fracturing in tight reservoir. The new fluid was tested in 65 wells in the tight gas and oil reservoir in western China. Oil &gas production after stimulation using the new fluid increased 2-5 times compared with wells in similar locations.

1. Introduction

The exploration areas of oil and gas are extensive in China, but faced with complexly geological characteristics with low porosity and permeability.it becomes inevitable to adopt reservoir stimulation so as to maintain their economic development that makes strict demands on protecting reservoirs with characteristic of "low damage". Fracturing fluid system is the key to successful reservoir stimulation during the fracturing process. It has proved that fracturing fluids provide a more efficient and environmentally friendly way to develop reservoirs. We should reduce reservoir damage and improve the research of efficient fracturing technology, build a new applied technology of fracturing fluid with "low-cost, low-damage, environmental protection". In this paper, a novel non-residual fracturing fluid was developed (Figure 1).

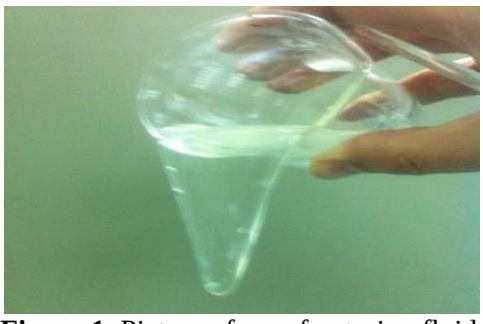

Figure 1. Picture of new fracturing fluid.

This fracturing fluid system is cross-linked under acid condition, and owns the advantages of fast dissolving, excellent sand carrying ability, non-residual, good anti-swelling property and low damage etc. Experimental results show that this system viscosity can reach 95% of peak viscosity in 3 minutes, the surface tension of the gel breaking liquid is 25 mN/m ,the residue content of the gel breaking fluid is 10mg/L, core permeability damage rate less than 15% which greatly reduces the damage to formation and man-made fracture conductivity. The new fluid was tested in 65wells in the tight gas and oil reservoir in western China. Oil &gas production after stimulation using the new fluid increased 2-5 times compared with wells in similar locations. Furthermore, it is expected to reduce direct costs of about 550 million yuan annually in petroleum industry in China, thus becoming an alternative fracturing fluid [1].

2. Main material

Fracturing fluid temperature and resistance to shear, gel, filtration and residue content based on the oil and gas industry standard SY/T5107-2005 "water base fracturing fluid performance evaluation method" to determine. Evaluation of the use of fracturing fluid formula: 0.30%A-1+0.2%B-1+0.3%KCl+0.5%C-1+0.5%D-1, the use of organic zirconium as a crosslinking agent, crosslinking ratio of 100:0.4. The main ingredients are as follows: cellulose A-1, tackifierB-1, crosslinking agent F-1, additive D-1.

3. X-ray experiment analysis

Comparing the photos of modified material focus on before or after dissolution by electron microscopy scanning, it is clear that the swelling of new material has dissolved drastically as shown in figure 2 and figure 3. The solubility of the modified material has been greatly enhanced with special characteristics of rapid dissolving [2], it is clear that the laminated structure of base-liquid material is in echelon [3]. Material gel has formed a dense-spatial-network structure by cross-linked carboxyl group, greatly improving temperature resistance and carrying capacity [4].

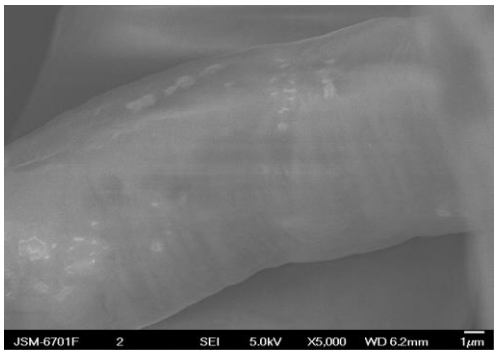

Figure 2. Fracturing material before dissolving.

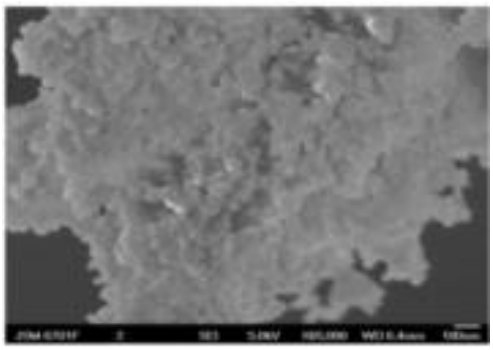

Figure 3. Fracturing material after dissolving.

3.1. Temperature factor analysis of fracturing fluid

This paper studies the hydroxypropyl guar gum, carboxymethyl guar gum base fluid temperature resistance was seen in table 1. Table 1 shows 90 ℃ and 120 ℃ under the conditions of shear for a certain period of time, when the temperature return to the starting temperature (30 ℃), hydroxypropyl guar gum and carboxymethyl guar gum viscosity can recover more than 93%, taking into account the instrument error, that is to say the chemical bond gum molecular chain basically no fault open; when the temperature reached 160℃, the recovery rate of viscosity is below 25%, indicating guar gum molecular chemical bond will be broken at the temperature.

3.2. Shear properties

At 80℃, 170s^{-1}, Nevinne shear performance measurement model of clean fracturing fluid using HAAKE-RS600 rheometer, the results are shown in figure 4. The shear viscosity of fracturing fluid for 90min, 260mPa.s, it has good resistance to high temperature and shearing performance and can meet the requirements of fracturing in tight reservoir[5].

Table 1. Hydroxypropyl guar gum and carboxymethyl guar gum temperature resistance

	Temperature ℃	Time Min	Viscosity MPa.S
0.4%HPG	90	1.5	41
0.4%HPG	120	2	42
0.6%HPG	160	2	28
0.4%CMHPG	90	1.5	45
0.4%CMHPG	120	2	45.6
0.6%CMHPG	160	2	25

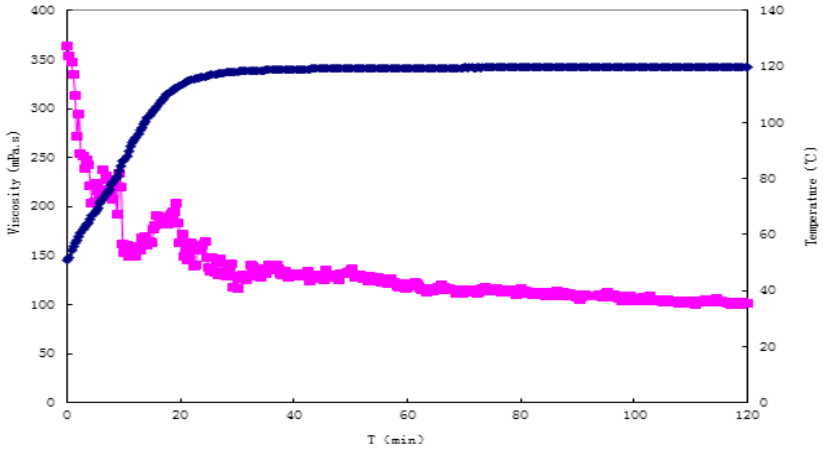

Figure 4. Temperature resistance and shear resistance about 0.3% material.

3.3. Fracturing fluid property

3.3.1. Filtration performance. Fracturing fluid filtration effect of fracturing fluid fracturing capacity, the greater the filter loss, the lower the efficiency of the fracturing fluid, the difficulty of the fracturing construction, the greater the damage to the reservoir. This paper evaluates the ultra-low concentration of hydroxypropyl guar gum fracturing fluid formula system of 120 ℃ filtration performance. Taking into account the filtrate loss of diesel, adding 0.5% diesel in fracturing, compared the filtration performance results show that the 5MPa pressure difference, the temperature of 120 ℃, liquid filter loss performance without adding diesel with conventional fracturing fluid, add diesel after filtration has a lower rate, at the beginning of filtration and filtration coefficient.

3.3.2. Study on the mechanism of cross linking. The effects of crosslinking agent in water complexation and repeated hydrolysis, hydroxyl bridge has complexions of polynuclear hydroxyl bridge with positive charge; modified carboxymethyl material base electronegative, polynuclear olation complex ion with modified material in carboxyl and Xian formed polar bond and coordination

bond and stock exchange [6]. In this paper, using organic zirconium as crosslinking agent of fracturing fluid acid complex, organic zirconium produced polynuclear olation complex ion in water complexation and multiple hydrolysis, hydroxyl bridge, positive charge polynuclear olation complex ion with high, and high metal ions to form coordination bonds; and the thickening agent the COOH band negatively, oxygen and nitrogen with lone pair electrons, polynuclear olation complex ion is formed by polar bonding and ligand healthy cross-linked with thickening agent in carboxyl and amide groups, the crosslinking reaction is as follows: (1) organic zirconium + H+, hydroxyl zirconium hydroxyl ion; (2) zirconium ion and polynuclear hydroxyl ions by bridge; (3) polynuclear olation complex ion + crosslinking agent, crosslinking gel[7].The first step is to restrict the reaction speed of the crosslinking agent. The ligands and the formation of Zr+ organic zirconium chelate ring, with strong, slow down the process of dissociation of organic zirconium, controlled the formation rate of hydroxy and hydrous zirconium ions, thereby delaying the crosslinking reaction speed, the system with delayed crosslinking, but by adjusting the size of crosslinked pH and ion concentration of the environment. Adjust the crosslinking time [8].

4. Field test

At present, new fracturing fluid system has been successfully applied in tight gas reservoirs in 65 wells field tests show that the new material residue fracturing fluid system has simple preparation, rapid dissolution, base fluid without fisheye and controllable delayed crosslinking, strong carrying capacity and breaking characteristics of glue thoroughly, no residue etc. Site construction of low friction, the average reduction rate of 78%, construction of the largest displacement of $8m^3/min$; cracking ability and sand carrying ability, the highest single well liquid level of 1450 m^3, the largest single sand volume is $96.5m^3$, average sand ratio 30%; Flow back fluid viscosity is 1.18mPa.s, average flow back rate is 81%, discharge time is reduced from the conventional guar gum fracturing fluid of 20h to 48h, after the pressure is 3-8 times the average daily production of adjacent wells. The new fracturing fluid system transformation of S1 well non main gas bearing, before the pressure of no production, obtained high yield unimpeded flow of $13 \times 10^4 m^3/d$ pressure, and good control of fracture height, no water phenomenon, is 3.3 times the same wells group of guar gum fracturing fluid applications. The result shows that the fracturing fluid with no residue is better to reduce the damage to the reservoir, especially to the tight gas reservoir.

5. Conclusions

China's oil and gas reservoirs are widely distributed and the exploration potential is tremendous, but with the more and more low permeability reservoirs have become the mainly oil production potential trend. Hydraulic fracturing treatment has been playing an important role in oil and gas industry which is a well-stimulation technique in which rock is fractured by a pressurized liquid. Therefore, it is very important to apply low-damage fracturing fluid in oil and gas field. In this study, a novel non-residual fracturing fluid was developed. New fracturing fluid has good temperature and shearing performance, sand carrying capability, anti-filtration performance, can meet in tight gas reservoir reconstruction requirements. New fracturing fluid has the advantages of no residue, its anti-swelling, very good to improve traditional guar gum and its derivatives are serious problems such as a large number of fracturing fluid residue, clay swelling, greatly reduce the damage to the reservoir. The new fluid was tested in 65 wells in the tight gas and oil reservoir in western China. Oil &gas production after stimulation using the new fluid increased 2-5 times compared with wells in similar locations. It provides an effective low damage fracturing fluid for the development of the region.

Acknowledgments

This work is supported by the National Science and Technology Major Project (NO. 2016ZX05023). The authors would express their appreciation to the project for contribution of research fund. The authors would also like to thank lab staff for carrying out the experiments.

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