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RESEARCH PAPER

Experimental evaluation of fracture stabilizers

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Abstract: To avoid the closure of once created fractures in unconsolidated sandstone reservoirs after fracturing, an optimum fracture stabilizer was selected through experimental evaluation, dosage optimization and analysis of its suitability with other commonly used fracturing fluids. A modified resin was selected as the fracture stabilizer, which can form an adhesive film with certain adhesion intensity on the surface of the proppant to fill fractures despite the slightly decreased conductivity. The conductivity, sand control effect, suitability with guanidine gum and viscoelastic surfactant fracturing fluids (VES) of fracture stabilizers with different ratios were evaluated in the experiment. The dosage of the fracture stabilizer was optimized according to conductivity results and sand control effect. After a comprehensive evaluation, fracture stabilizer of 3% to 5% mass fraction is recommended to be used with the guanidine gum fracturing fluid. The simulation experiments show that the flow conductivity of fractures could be maintained by fracture stabilizers and in the proppant processed by stabilizers the number of intrusive particles was significantly reduced.

Key words: fracture stabilizer; conductivity; sand control effect; fracturing fluid

Introduction

In fracturing fluid flowback and production process of unconsolidated sandstone, fractures are not stable due to loose cementation and large output liquid velocity[1–3]. Fracture stabilizer is a kind of viscous polymer compound used to maintain stable fracture shape, it can be mixed with proppant above ground or directly injected into fractures. Fracture stabilizer plays an important role in keeping fracture morphology and conductivity, and reducing sand invasion. Its main working mechanism is that it can increase cementation between proppant.

At present, there are few research and application on fracture stabilizers. There are some reports on the application of coated sand and SMA material, but their adaptability to different fracturing fluids and sand control effect haven't been examined[4-14]. Conductivity, sand control effect, and compatibility with commonly used fracturing fluid of fracture stabilizer were evaluated by experiments. The dosage of fracture stabilizer was optimized according to conductivity results and sand control effect.

1 Fracture stabilizer component and function mechanism

The fracture stabilizer mainly includes modified resin (main component is optimal furan resin), curing agents, coupling agents and other additives. Resin materials widely used in chemical sand consolidation, have linear, mesh, and other molecular structures, with various and relative small molecular mass.

There is affinity function between strong polar groups in modified resin molecules and proppant surface polarity groups, hence modified resin molecules will migrate and adhere to proppant surface. At formation temperature, the molecular structure of modified resin will change, resulting in the rise of viscosity in curing process. After curing process, a layer of viscous membrane with certain intensity will form on proppant surface, which will slightly reduce the fracture conductivity, but can stop relative movement between proppant grains, hence strengthen fracture stability. The modified resin after curing has strong acid, alkali and organic solvent erosion resistance, as well as good stability at high temperature. For different reservoirs, the ratio of curing agent, coupling agent and modified resin can be adjusted to get desired curing degree and speed.

2 Fracture conductivity evaluation experiment

Fracture stabilizer is mainly used in unconsolidated sandstone reservoirs where the fractures are apt to fail after fracturing. According to physical parameters of an unconsolidated

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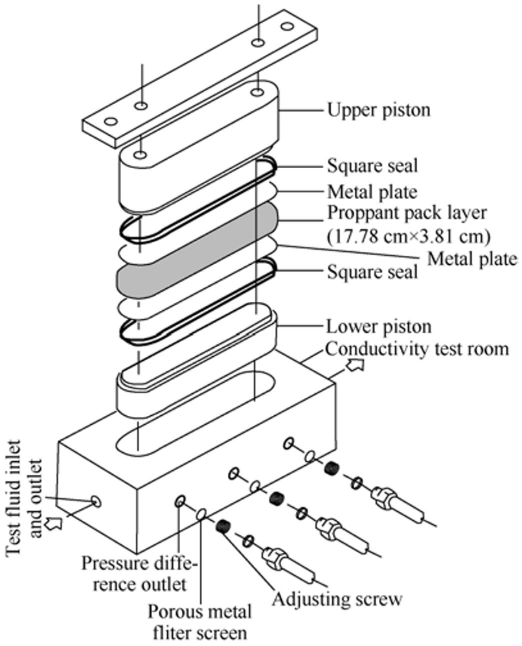

Fig. 1 Structure of conductivity test instrument

sandstone reservoir in the Bohai oilfield, we selected 0.42 – 0.85 mm (40 – 20 mesh) Carbo proppant as study object. Firstly, mix the fracture stabilizer and proppant at given proportions, put the mixtures in incubator at formation temperature (60 ℃) for 8 hours, then test the conductivities using FCES-100 conductivity test device at formation temperature (Fig. 1). The conductivity of untreated proppant was also tested for comparison. Generally unconsolidated reservoir has low formation pressure, hence closure pressures were all set under 40 Mpa in this experiment.

It can be seen from Fig. 2 that conductivity decreases with the increase of stabilizer mass fraction, therefore, in practical application, the dosage of stabilizer shall be determined by considering conductivity loss and sand control jointly. When the mass fraction of the fracture stabilizer is less than 5%, with the increase of closure pressure, the conductivity difference from the original proppant gets bigger and bigger. When the mass fraction of the fracture stabilizer is more than 5%, the reduction of conductivity caused by the increase of stabilizer decreases with the increase of closure pressure. According to the analysis of outflow liquid, when the mass fraction of the fracture stabilizer is more than 5%, some of the fracture stabilizer drain with the outflow liquid, which means proppant has been fully coated, excess fracture stabilizer will flow away in long-term conductivity experiment.

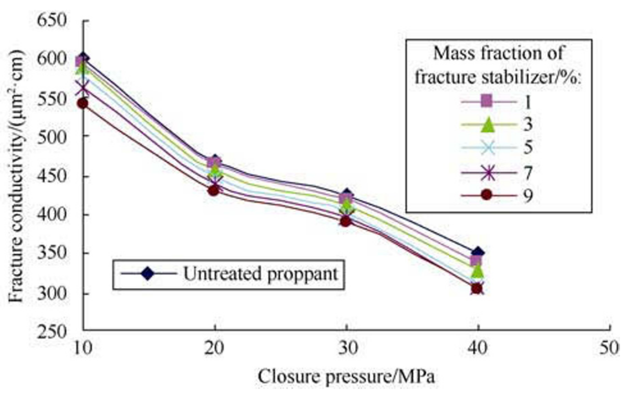

Fig. 2 Fracture conductivity at different mass fractions of fracture stabilizer

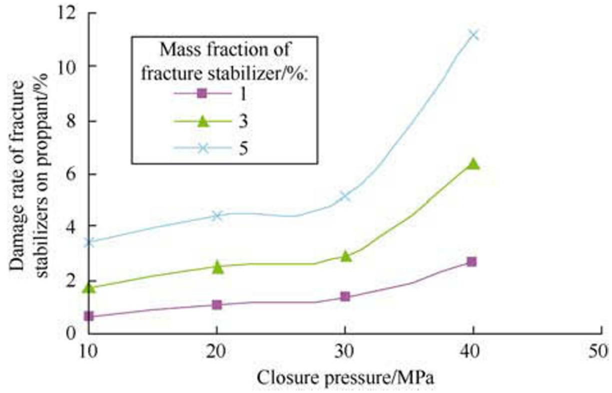

Fig. 3 Relationship of proppant conductivity damage rate with mass fractions of fracture stabilizer

Here we define the damage rate of fracture stabilizers on proppant as the ratio of fracture conductivity after adding fracture stabilizers to the original conductivity.

As can be seen from Fig. 3, with the increase of closure pressure and fracture stabilizer dosage, the damage rate increases, the higher the closure pressure the faster the damage rate increases.

3 Sand control effect experiment of the fracture stabilizer

Since it is difficult to get unconsolidated sandstone cores and to make them match the shape of conductivity test room, so we made artificial cores based on the actual particle size distribution of unconsolidated sandstone in the Baohai area as shown in Table 1. By adding cementitious particles, the density, cement bond conditions and embedment of artificial core were nearly the same as the real formation core. According to the principle of Saucier which is widely used in oilfields, we selected 20-40 mesh proppant.

Fracture stability and sand control effect under flow condition were evaluated at formation temperature. In the core holder, we put 0.25–0.42 mm (60–40 mesh) proppant, 0.42–0.85 mm proppant, artificial core from outlet to inlet to simulate the movement of formation sand into proppant. The experimental ring pressure was 5 MPa, inlet pressure was 3 Mpa, outlet pressure was atmospheric pressure, diesel was pumped into inlet for 8 hours.

Table 1 Unconsolidated sandstone size distribution

Particle diameter/mm	Mass fraction/%	Particle diameter / mm	Mass fraction /%
0.85–2.00	13.63	0.15–0.25	15.50
0.59–0.85	10.73	0.089 – 0.15	16.76
0.42–0.59	4.96	0.074 – 0.089	19.22
0.25–0.42	6.84	<0.074	12.36