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A comprehensive experimental study for optimization of fracture stabilizers

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HIGHLIGHTS

- Comprehensive evaluation of long term sand control and conductivity maintain.
- Compatibility with commonly used fracturing fluid of fracture stabilizer was evaluated.
- Dosage of fracture stabilizer was optimized.

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ABSTRACT

A Gum fracturing fluid compatible fracture stabilizers was selected through experimental evaluation in the former research. The simulation experiments show that the flow conductivity of fractures could be maintained by fracture stabilizer, and the number of intrusive particles in the proppant processed by stabilizers was significantly reduced. The dosage of the fracture stabilizer was optimized according to comprehensive experiments of long term conductivity and sand control effect under condition of bilinear flow. Results showing that conductivity decreases over time and reaches steady state after 5 days. The conductivity reduction decreases with the increase of stabilizer mass fraction. After a comprehensive evaluation, fracture stabilizer of 3–5% mass fraction is recommended.

1. 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.

There are some reports on the application of coated sand and SMA material, but few on comprehensive evaluation of long term sand control and conductivity maintain [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.

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.

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In the former research [15], the conductivity and sand control effect of a Gum fracturing fluid compatible fracture stabilizers with different ratios were evaluated in experiment. The dosage of the fracture stabilizer was optimized according to conductivity results and sand control effect.

It can be seen from Fig. 1 that conductivity decreases with the increase of stabilizer mass fraction. 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.

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. 2, 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.

As can be seen from Fig. 3, When stabilizer mass fraction is less than 5%, invasion sand mass fraction decreases rapidly. When stabilizer mass fraction is more than 5%, invasion sand mass fraction nearly remain the same.

Combine Figs. 2 and 3, when stabilizer mass fraction is more than 5%, the reduction of conductivity becomes larger, while sand control effect does not improve anymore.

2. Long term comprehensive experimental study of the fracture stabilizer on fracture conductivity and sand control

Comprehensive experiments were carried out to evaluate effect of fracture stabilizer on conductivity and sand control in long term under the condition of bilinear flow. Experiments with 3–9% mass fraction of the fracture stabilizer will be evaluated in the following section.

Experiment setup was modified from conductivity test equipment shown in Fig. 4. A sandwich layer, from top to bottom including artificial core – proppant – artificial core, was put in the position of proppant layer in Fig. 4. Then remove the metal plate, add vertical flow perpendicular to the sandwich layer through inlet on piston, to simulate the bilinear flow in reservoir, as the arrows mark.

Since it is difficult to get unconsolidated sandstone cores and to make them match the shape of conductivity test cell, 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.

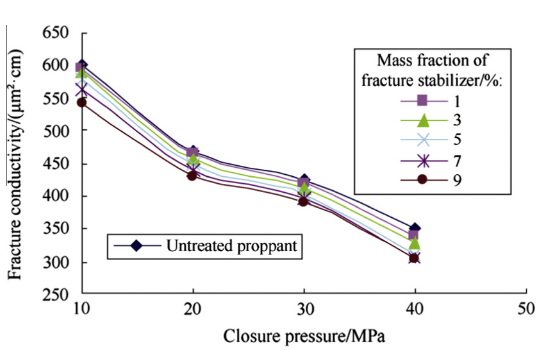

Fig. 1. Fracture conductivity at different mass fractions of fracture stabilizer.

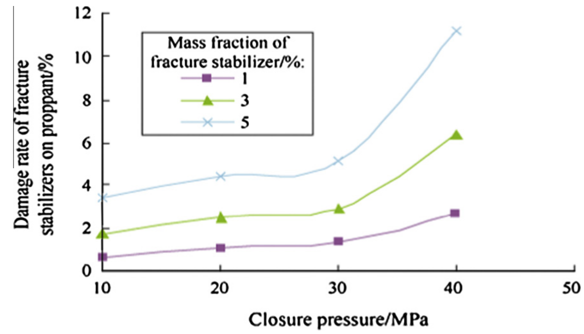

Fig. 2. Relationship of proppant conductivity damage rate with mass fractions of fracture stabilizer.

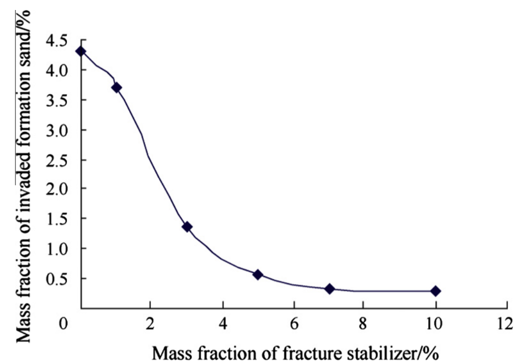

Fig. 3. Relationship of invasion formation sand fraction in the mixture with stabilizer mass fraction.

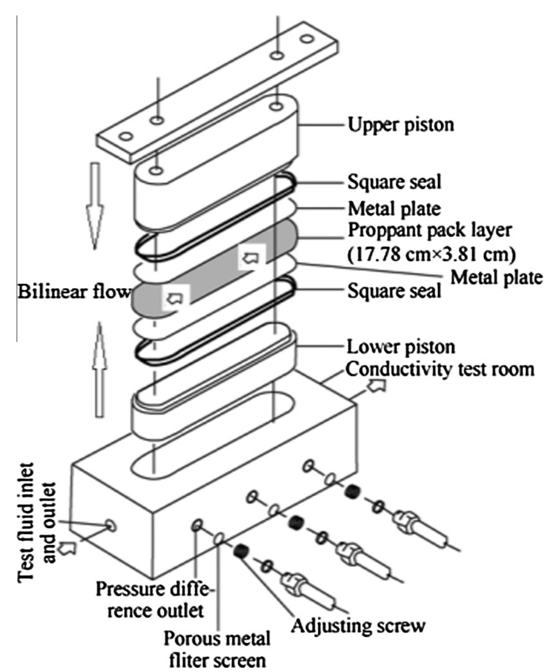

Fig. 4. Structure of conductivity test instrument.

According to the principle of Saucier which is widely used in oilfield, we used 0.42–0.85 mm (40–20 mesh) Carbo proppant. The proppant concentration was 15 kg/m^2, artificial core thickness was 5 cm, corresponding formation pressure was 15 Mpa, test cell area was 65 cm^2. In view of the high production of unconsolidated sandstone reservoir and test cell area, kerosene was injected into