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Classification and Research Progress of Fracturing Fluids

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Abstract: As one of the important technical means to increase production in oil and gas fields, the success or failure of fracturing construction and the effect of increasing production depend largely on the performance of the fracturing fluid used. This paper analyzes the fracturing fluid systems used in different coal seams at home and abroad, and lists the research progress of several fracturing fluid systems, which plays a guiding role in the selection of fracturing fluids in the development of oil seams.

Keywords: Fracturing Fluid; Low-permeability; Coal Seams Application Status.

1. Introduction

In recent years, with the development of unconventional oil and gas reservoirs becoming more and more common, hydraulic fracturing technology has been widely used in the field and gradually become an indispensable means for oil and gas wells to increase production and production. The main mechanism of hydraulic fracturing technology is to use a high-pressure pump set on the ground, and the principle of liquid pressure transfer will be used to inject fracturing fluid into the reservoir with a displacement greater than the absorption capacity of the reservoir, form a high-pressure pressure to open artificial cracks in the wellbore, and then inject sand carrying liquid containing proppant into the cracks to support the cracks to form several high diversion channels that can be used for oil and gas migration, so as to achieve the purpose of increasing production and injection. [1]

Fracturing fluids contain thickeners, cross-linking agents, temperature stabilizers, etc., which have the functions of transferring pressure, carrying proppants, forming and extending cracks, etc. As an extremely important part of hydraulic fracturing, its performance is directly related to the effect of fracturing and production increase. Fracking fluids need to have good rheology, sand suspension, high temperature resistance and low residue properties, as well as be able to reflow quickly and cause little damage to the formation.

As drilling depths increase and formation conditions become more complex, fracturing fluids with better performance, less damage, and lower cost have been the goals pursued by researchers. In this paper, different types of fracturing fluids are listed, and the performance mechanism and research progress of various fracturing fluids are reviewed.

2. Fracking Fluid Application Status

2.1. Clean Fracturing Fluid

Clean fracturing fluid, also known as VES fracturing fluid, is a low-harm fracturing fluid that uses VES as a thickener. VES fracturing fluids can be formulated from many types of surfactants, including anionic surfactants, cationic surfactants and amphoteric surfactants, and quaternary ammonium salt cationic surfactants are currently the most widely used. [2]

The technological breakthrough of clean fracturing fluid lies in the use of VES instead of polymer as fracturing fluid thickener, which is characterized by easy glue-breaking, basically no residue after glue breaking, and relatively thorough backflow, which can not only effectively carry proppant, but also greatly reduce the damage to the reservoir and ensure the recovery rate of oil and gas wells.

Due to the advantages of low damage and high backflow rate, VES fracturing fluid is more commonly used at home and abroad. As of the beginning of the 21st century, the use of VES fracturing fluid in foreign countries has been successfully operated more than 2,000 times, forming a series of clean fracturing fluid systems, which have obvious seam control and improve fracture diversion capacity compared with polymer fracturing fluid. Since the introduction of VES fracturing fluid technology developed by Dowell and its first application in the Sichuan Basin [3], it has set off an application boom, and is currently mostly used in fracturing transformation of coalbed methane reservoirs, aiming to reduce coal seam injury.

2.2. Polymer Fracturing Fluids

Polymer fracturing fluids are divided into natural polymer fracturing fluids and synthetic polymer fracturing fluids. Due to the high cost of VES fracturing fluid, which restricts its popularization, synthetic polymer fracturing fluid has the advantages of strong thickening ability, no residue, and low damage to formation compared with natural polymer, so it has become a hot spot in domestic and foreign research.

Due to the great influence of temperature, pH and other conditions on the properties of synthetic polymers, the research enthusiasm of polymer modification has never decreased, and the temperature resistance and salt resistance of polymer fracturing fluid can be improved by starting from the modification of thickeners and the research of cross-linking agents. [4]

2.3. Foam Fracturing Fluid

Foam fracturing fluid includes foaming agent, foaming stabilizer, etc., which can be divided into four types: water-based, acid-based, alcohol-based and liquid carbon dioxide-based, among which water-based fracturing fluid is the most widely used. It is characterized by small filtration loss, low damage to the formation, easy recharge, and has the advantages of high viscosity and strong sand carrying capacity compared with active water fracturing fluid.

In view of the poor temperature resistance and foam instability of foam fracturing fluid, the researchers compounded the original foaming agent, which not only solved the problem of poor stability of a single foaming agent, but also saved costs compared with the development of new foaming agents. At the same time, CO_2 foam fracturing fluid is also a key research object, which is widely used in coalbed methane reservoirs due to its low filtration loss and high backflow. [5]

3. Research Progress of Fracturing Fluids

3.1. Clean Fracturing Fluid

In recent years, people have been committed to overcoming the problem of poor temperature resistance of VES fracturing fluid, and strive to achieve good rheology and filtration of fracturing fluid under medium and high temperature conditions. Foreign companies rely on the network structure in the research and development process to effectively increase the viscosity of clean fracturing fluid at high temperature, so as to promote the enhancement of the sand carrying capacity of fracturing fluid. In order to solve the problems of poor temperature resistance, water lock, and high residue rate of fracturing fluid system, Yanchang Gas Field developed a Slickwo online fracturing fluid system, and indoor and field experiments showed that the viscosity of shear 90min at 120°C was about 50mPa·s. The anti-expansion rate is 80%; Core damage rates < 15% and good adaptability to reservoirs. [6]

3.2. Polymer Fracturing Fluids

Based on the large-scale development of horizontal wells, in order to solve the problems of high concentration of drag reducing agent, slow dissolution rate and poor viscosity ability used in polymer fracturing fluid, the research on variable viscosity fracturing fluid system was carried out. Li Yang et al. synthesized a new low-concentration polymer fracturing fluid for the purpose of instant dissolution, viscosity enhancement and drag reduction. The experimental results showed that the low viscosity drop resistance rate was 79.46% and the high viscosity drop resistance rate was 70.01%. And when the concentration of the resistance reducing agent is low, the aggregate is dispersed, the viscosity is 2.74mPa·s at 0.05%, the aggregate is combined into a spatial grid structure when the concentration is high, and the viscosity is 18.56mPa·s at 0.3%, which can realize the free conversion between the polymer and the sand-carrying solution. Experiments show that the system has the characteristics of low concentration, high drag reduction rate and strong sand carrying performance. [7]

3.3. Foam Fracturing Fluid

In the seventies and eighties of the twentieth century, in order to improve the weakness of low viscosity and poor stability of foam fracturing fluid, researchers added polymer thickeners and high-efficiency foaming agents to it, which made foam fracturing achieve good production increase in domestic and foreign oil and gas fields. In order to make the foam fracturing fluid can be applied to high-temperature deep wells, the polymer is formed into a high-strength network cross-linked structure by crosslinker, which greatly increases the stability and temperature resistance of the fracturing fluid. In order to meet the low injury requirements of unconventional oil and gas operations, Zhang and Pierce used VES clean fracturing fluid foaming for the first time to obtain a clean foam fracturing fluid system, which greatly reduces the damage to the formation because it is polymer-free and cross-wound worm-like micelles in the base fluid also enhances foam stability and filtration resistance, and the system has achieved good fracturing and production increase in Australia, Russia and other countries. [8]

4. Tag

Clean fracturing fluid has low friction resistance, less filtration loss, basically no residue, and the disadvantage is that its hydration and expansion damage and high cost.

Polymer fracturing fluid has the characteristics of strong thickening ability, insensitivity to bacteria, good stability of frozen glue, strong sand suspension ability, low residue, low damage to the formation, etc., and the disadvantages are that it is not resistant to high temperature and poor shear stability.

Compared with clean fracturing fluid, foam fracturing fluid has the advantages of strong economy, high energy and easy reflow. Compared with polymer fracturing fluid, it has the advantages of high energy, easy reflux and low formation damage. Therefore, compared with the other three fracturing fluids, foam fracturing fluid is more suitable for low-temperature low-porosity low-permeability coalbed methane reservoirs.

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