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Fracture Conductivity Using Emulsified Acids: Effects of Emulsifier Concentration and Acid Volume Fraction

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Abstract

None uniform acid etching of the face of the fracture is the primary cause of fracture conductivity in acid fracturing. The retained conductivity of the fracture after the acidizing depends on many factors some pertaining to the rock texture, some to the acidizing conditions and others to the treating fluids. Previous research focused on the texture of rock and acidizing conditions such as flow rates, temperature and contact times. These parameters along with the type of acid used proved to affect the fracture conductivity as was shown in previous research. This paper focuses on the fracture conductivity after acidizing it with the emulsified acids. The objective of this work was to study the effect of droplet size, acid volume fraction and emulsifier concentration on the fracture conductivity.

Indiana limestone rocks were acidized with different formulations of emulsified acid. A 15 wt% HCl in diesel emulsion with 0.5, 0.6 and 0.7 acid volume fractions and with emulsifier concentrations of 1, 5 and 10 gpt were used in the tests. The tests were run using a modified API conductivity cell at 200oF and 1,000 psi. Each test was run for 30 minutes at a flow rate of 1 Litter per minute. The experimental setup provided close approximation to the field conditions. The standard fracture conductivity measurements were done after each experiment and the etched fracture surfaces were characterized using a laser profilometer.

The results of the experiments showed that channeling and large-scale features on the etched surfaces were the dominant factors for fracture conductivity for the course emulsions. Higher acid volume fractions weakened the rock and caused the fracture to loss its conductivity faster at high closure pressures. When emulsions with smaller droplet sizes were used, the acid penetrated deeper inside the rock and caused small-scale features on the surface rather than channeling. This feature formed a mesh-like surface that was conductive even at high closure pressures. These new findings can be used to optimize the use of emulsified acid in the field.

Introduction

The purpose of acid fracturing treatment is to create a highly conductive fracture for the oil and gas to flow easily from the formation into the wellbore. The process involves pumping a viscous fluid at high rates and pressures that create and extend a fracture inside the formation. The acid is used as a part of this process to etch the fracture face and leave a conductive pathway to effectively produce reservoir fluids. After the fracture is created, an acid is injected and as it contacts the fracture walls, it reacts with the rock face, creating uneven surfaces which should result in a conductive pathway when the fracture is closed.

The final conductivity of the fracture is dependent on (1) factors that create the conductive path and (2) factors that retain the conductive path after fracture closure. The primary goal of the first group is the differential etching of the fracture surface. Differential etching depends on fluid properties such as acid reaction time, fluid efficiency, acid type, contact time, temperature; and rock properties (Broaddus 1968; Nierode and Kruk 1973; Anderson and Fredrickson 1989).

The second group of factors deals with variables that can destroy the conductive path once the fracture closes. The primary reason for losing the conductivity is the closure stress trying to close the fracture. Acting against closure stress is the strength of the rock. Higher conductivities will be created when the contact points on the face of the fracture are strong enough to keep the fracture open. When the rock is soft the contact points if any will be crushed and the fracture will loss its conductivity at high closure pressures. The acid also might soften and weaken the rock and cause it to lose conductivity. For example, Broaddus (1968) stated that large quantities of acid and long contact times may soften the fracture face and cause