Improved acid stimulation in carbonates: Impact of acid types and flow rate on reactive transport mechanisms

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Abstract

Acid stimulation in carbonates is a reactive transport mechanism where transport dynamics are coupled with reaction kinetics. Accurate description of reactive transport in heterogeneous porous media still represents a scientific challenge. One of the main objectives of acid stimulation treatments in carbonate reservoirs is to achieve a good zonal coverage with the acid, especially to unlock low permeability hydrocarbon regions. However, field applications show that acid stimulation leads to a poor increase of permeability in the targeted region as well as an increase in water production. In this joint research program between Qatar Petroleum and TOTAL, we aim to develop and test novel pumping sequences of fluids in order to improve acid stimulation efficiency in mature carbonate reservoirs. We performed high pressure and temperature single and dual core flooding experiments over a range of four different carbonate samples with different permeabilities and pore structures. Live and emulsified acids were used as well as Relative Permeability Modifiers (RPMs) and particle-laden diverters. Changes in permeability were measured in real time during the injection across the length of the cores. In addition, pre and post-injection micro-CT scanning allowed the visualization of different dissolution patterns (mainly dominant wormholing). Changes in porosity induced by the chemical reactions were also deduced based on image analysis. We compared the response of different acid types and assess the impact of RPMs on brine and oil flow. Results show the impact of flowrate and acid type on reactive transport mechanisms. The measurements of pore volume to breakthrough are discussed. The insights into different pumping strategies can be used to different other applications such as carbon storage in heterogeneous carbonates.