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Experimental Investigation of Improved Acid Stimulation in Carbonates

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SUMMARY

In this study, we aim to experimentally revisit standard acid stimulation techniques and to test novel pumping sequences including water mitigation and diversion. After state of the art characterization of the selected carbonate samples, injections of acidic solutions are performed at elevated temperatures and pressures using dedicated single and dual core apparatus at the core scale. It has been found that, wormholing behavior and mainly the pore volume to breakthrough is strongly dependent on the acid type and the pumping mode. For retarded acids, such as emulsified acids, the existence of the optimum pore volume to breakthrough is challenged. The efficiency of different pumping sequences on water mitigation and diversion is discussed.

Keywords: single core, dual core, pore volume to breakthrough, acid stimulation, experiments, diversion.

Abstract

Characterizing the injection of an acidic solution in carbonate porous media remains a challenging scientific problem. In this study, we aim to experimentally revisit standard acid stimulation techniques and to test novel pumping sequences including water mitigation and diversion. First, a series of carbonate samples are carefully selected and characterized, using petro-physical measurements of X-RD, MICP and NMR, as well as high resolution imaging techniques. Subsequently, injections of acidic solutions are performed at elevated temperatures and pressures using dedicated single core apparatus at the core scale (30 cm length). Different acid types and flow rates are investigated and the impact of permeability and pore structure on acid stimulation efficiency are assessed. Real time pressure changes across the core and along the samples are measured. The pore volume to breakthrough is obtained. Pre and post injection computed tomography scans are conducted. Finally, after establishing an understanding for the role of permeability on wormholing in simple configurations, a series of elevated temperature and pressure dual core experiments are performed. Different permeability contrasts are investigated and different pumping sequences including polymers such as Relative Permeability Modifiers and chemical diverters are used. The pressure is monitored in real time across both core samples. It has been found that, wormholing behavior and mainly the pore volume to breakthrough is strongly dependent on the acid type and the pumping mode. For retarded acids, such as emulsified acids, the existence of the optimum pore volume to breakthrough is challenged. In addition, injection at constant pressures lead to faster propagating wormholes. Moreover, the adsorption efficiency of selected polymers in carbonates is assessed and the efficiency of different pumping sequences on water mitigation and diversion is discussed. The insights learnt from experimental observations addresses a series of scientific questions that could be tackled by developing numerical models of acid stimulation and field trials. The insights learnt regarding reactive transport could be transferred to other applications such as Carbon Storage and Enhanced Oil Recovery.

Keywords: single core, dual core, pore volume to breakthrough, acid stimulation, experiments, diversion.