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Impact of varying acid injection rate and fluid saturation on carbonate matrix acidizing: highlighting the importance of pore structure.

Oussama Gharbi[1], Nour El Cheikh[1], Priyank Maheshwari[1], Philippe Julien[1]

[1]TOTAL E&P Qatar, Doha , QATAR

ABSTRACT

Injection of an acidic solution in oil and gas wells producing in carbonate reservoirs is a standard well intervention technique that could lead to a significant increase in production. This is a reactive transport phenomenon where the chemical dissolution of the carbonate porous media is coupled with the flow within the pore space. The optimum design of this intervention technique is a crucial step, as the choice of the injection mode is defining the outcome in-terms of hydrocarbon production. The aim of this study is address the importance of pore structure, fluid saturation and pumping mode on acid stimulation.

A series of novel core flooding experiments, using carbonate outcrop cores and 15 wt. % HCl acid were performed. All the experiments were performed at a temperature of 95°C and a pressure of 250 bar, eliminating the effect of CO_2 on the measurement of pore-volume to breakthrough (PVBT).

Differential pressure along and across the core samples,

flow rates, and temperature were recorded during the experiments. We first performed constant flow rate core-flooding experiments corresponding to the dominant wormholing regime. Then, experiments were switched to constant

injection pressure mode. Finally, the saturations of in-situ fluid were varied using different brine-oil configurations. Moreover core-scale acidization simulations were performed using an in-house 3D acidization simulator that is capable of reproducing the experimental data.

We show that dissolution regimes obtained at a constant pressure mode (CPM) are completely different when compared to constant rate mode (CRM). Dissolution that started in the face dissolution regime switches towards wormholing regime during CPM unlike CRM. Further, we show a strong dependency of the dissolution phenomenon

on the fluid saturation. Acidization of oil-saturated core leads to lower PVBT when compared to the core saturated with brine. This effect is further enhanced in low-permeability cores. These are signs of the importance of the pore size distribution on dissolution regimes. For example, the effect of pore structure is highlighted in the case of the imbibition process of acid injection into oil-saturated water-wet cores where the acid is first flowing into the smaller connected pores due to the capillary forces. The observations from the experimental and modeling studies were translated into guidelines to effectively stimulate the carbonate reservoirs.