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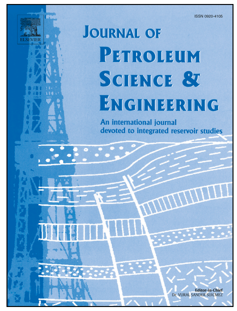

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A New Wormhole Propagation Model at Optimal Conditions for Carbonate Acidizing

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Abstract

Optimal injection conditions are important for carbonate acidizing design. Both experimental and theoretical work have been carried out for studying optimal injection rates, but rarely the optimal wormhole propagation velocities. In this study, we developed a mathematical model that can describe wormhole propagation at optimal conditions. This model incorporates rock pore size distribution and acid-rock reaction characteristics, which essentially includes every factor that affects optimal conditions.

Before developing our model, we studied the static pressure and flow field when a wormhole propagates to a certain length in a core plug through numerical simulations. Also, we carried out lab acidizing coreflood experiments to explore wormhole propagation behavior. The results show that when a wormhole reaches a certain length, the wormhole propagation velocity keeps the same. This is because a stable fluid loss profile is established after this length. Based on this finding, we focus on the wormhole tip. By incorporating an optimal tip flux model to a mechanistic model of wormhole growth, our new propagation model presents more fundamental mechanisms.

Our model shows that the wormhole propagation velocity depends on the rock pore size distribution and the overall reaction rate coefficient at optimal conditions. Particularly, if the reaction is fully diffusion-limited, it depends on the rock pore size distribution and the diffusion coefficient. These are verified by acidizing coreflood experiments at different acid concentrations and temperatures.

The findings of this study illustrate the importance of the overall reaction rate and diffusion rate. This model can be incorporated into an acidizing simulator for engineering design.

Introduction

For carbonate acidizing, it is well known that different acid injection rates result in significant stimulation differences. At low acid injection rate, acid tends to create a thick and short wormhole. Equivalently, wellbores were only enlarged but not stimulated. At high acid injection rates, wormhole branches are created along a dominant wormhole. The acid that creates branches