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Counter-Current Imbibition Distance in Tight Oil Reservoirs: Experimental and Numerical Simulation

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Abstract

Tight oil reservoirs, characterized by their low permeability and complex pore structures, present unique challenges in efficient oil recovery. Counter-current imbibition, a key process involving the displacement of oil by water in the opposite direction of the initial fluid flow, has gained significant attention as a potential enhanced oil recovery (EOR) mechanism in these unconventional reservoirs. This article presents a comprehensive study that combines experimental investigations and numerical simulations to elucidate the factors influencing the counter-current imbibition distance in tight oil reservoirs.

Keywords: Tight oil reservoirs; Counter-current imbibition; Enhanced oil recovery; Experimental study; Numerical simulation; Pore-scale modeling; Wettability; Capillary pressure; Oil displacement

Introduction

Tight oil reservoirs, characterized by their low permeability and complex pore structures, have emerged as a critical component of the global energy landscape. As traditional oil reservoirs become increasingly depleted, the exploration and production of unconventional resources have gained prominence [1]. However, the unique challenges posed by tight oil reservoirs necessitate innovative approaches to enhance oil recovery and maximize resource utilization. One such approach that has garnered significant attention is counter-current imbibition – a dynamic process that holds the potential to revolutionize oil recovery in these challenging reservoirs [2].

The term "tight oil" refers to hydrocarbons trapped within rock formations with extremely low permeability. Unlike conventional reservoirs, where oil can flow relatively freely through interconnected pore spaces, tight oil reservoirs present formidable barriers to fluid movement. This low permeability arises from the fine-grained nature of the rock matrix and the presence of various mineralogical constituents. Consequently, recovering oil from these reservoirs demands unconventional techniques that can exploit the intricate interplay between fluid properties, rock characteristics, and flow mechanisms [3].

Counter-current imbibition stands out as a promising mechanism that capitalizes on capillary forces and wettability effects to drive fluid displacement. In this process, water is injected into the reservoir from the opposite direction of the initial fluid flow, typically displacing oil towards the wellbore [4]. This approach harnesses the inherent capillary pressures within the reservoir matrix to encourage fluid movement, potentially leading to higher recovery rates and improved overall production.

The successful application of counter-current imbibition in tight oil reservoirs relies on a comprehensive understanding of its underlying principles and influencing factors. This necessitates a multidisciplinary approach that combines experimental investigations, numerical simulations, and advanced imaging techniques to elucidate the complex dynamics occurring at both macroscopic and pore-scale levels. By unraveling the intricate interactions between fluid behavior, rock properties, and reservoir geometry, researchers and engineers can tailor strategies to optimize counter-current imbibition and unlock the untapped potential of tight oil reservoirs [5, 6].

Experimental methodology

A series of core flooding experiments were conducted using representative tight oil core samples. The experiments were designed to mimic reservoir conditions and capture the intricacies of counter-current imbibition [7]. Core plugs were saturated with oil and subsequently imbibed with water from the opposite direction. Pressure differentials, fluid saturations, and imbibition rates were measured and analyzed.

Results and Discussion

The experimental results revealed the intricate interplay of various parameters influencing counter-current imbibition distance, including rock wettability, pore structure, and initial oil saturation. The observed imbibition rates and distances were correlated with key rock and fluid properties, shedding light on the mechanisms driving the process [8, 9].

Numerical simulation

A numerical simulation model was developed based on the experimental data and reservoir characteristics. The model incorporated complex pore-scale physics, considering factors such as capillary pressure, fluid viscosity, and interfacial tension [10]. Simulation scenarios were designed to investigate the effects of varying rock properties and operational parameters on counter-current imbibition.

Comparative analysis

Comparing experimental and simulation results allowed for a comprehensive understanding of the counter-current imbibition process. The simulation model's predictive capabilities were validated

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against experimental outcomes, demonstrating its utility in optimizing oil recovery strategies for tight oil reservoirs [11].

Implications and future directions

The findings of this study have significant implications for EOR strategies in tight oil reservoirs. The insights gained into the factors influencing counter-current imbibition distance can inform reservoir management decisions, leading to more effective oil recovery. Future research directions may involve incorporating advanced imaging techniques, such as micro-CT scanning, to visualize and quantify pore-scale fluid displacement during imbibition [12].

Conclusion

The combined approach of experimental investigations and numerical simulations offers a robust framework for unraveling the intricacies of counter-current imbibition in tight oil reservoirs. The insights gained from this study contribute to the optimization of oil recovery strategies in unconventional reservoirs, thereby advancing the sustainable utilization of tight oil resources.

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Conflict of Interest

None

References

1. Al-Mjeni R (2010) Has the time come for EOR? Oilfield Rev 22: 16-35.
2. Godec M (2000) CO2 storage in depleted oil fields: the worldwide potential for carbon dioxide enhanced oil recovery. Energy Proc 4: 2162-2169.
3. Zhang K, Jia N, Zeng F (2018) Application of predicted bubble-rising velocities for estimating the minimum miscibility pressures of the light crude oil–CO2 systems with the rising bubble apparatus. Fuel 220: 412-419.
4. Teklu TW (2017) Low salinity water–Surfactant–CO 2 EOR. Petroleum 3: 309-320.
5. Li S (2019) Diffusion behavior of supercritical CO2 in micro- to nanoconfined pores. Ind Eng Chem Res 58: 21772-21784.
6. Santos CI, Silva CC, Mussatto SI, Osseweijer P, van der Wielen LAM, et al. (2018) Integrated 1st and 2nd generation sugarcane bio-refinery for jet fuel production in Brazil: Techno-economic and greenhouse gas emissions assessment. Renew Energy 129: 733-747.
7. Wang WC (2016) Techno-economic analysis of a bio-refinery process for producing Hydro-processed Renewable Jet fuel from Jatropha. Renew Energy 95: 63-73.
8. Romero-Izquierdo AG, Gómez-Castro FI, Hernández S, Gutiérrez-Antonio C (2022) Computer aided-design of castor bean fruit-based biorefinery scheme to produce sustainable aviation fuel. Chem Eng Res Des 188: 746-763.
9. Bezergianni S, Dimitriadis A, Kikhtyanin O, Kubička D (2018) Refinery co-processing of renewable feeds. Prog Energy Combust Sci 68: 29-64.
10. Xing W, YS (2013) Research progress of the interfacial tension in supercritical CO2-water/oil system. Energy Procedia 6928-6935.
11. Shah A, RF (2010) A review of novel techniques for heavy oil and bitumen extraction and upgrading. Energy & Environmental Science 700.
12. Dai Z, RMR (2013) An integrated framework for optimizing CO2 sequestration and enhanced oil recovery. Environmental Science & Technology Letters 49-54.