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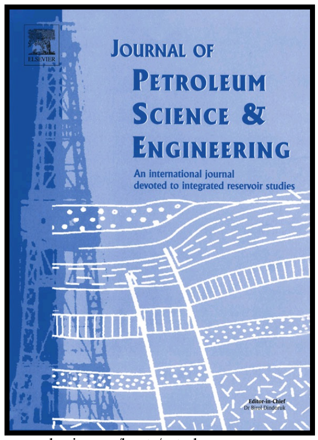

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D. Aleksandrov, P. Kudryavtsev, B. Hascakir

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Variations in In-Situ Combustion Performance due to Fracture Orientation

D. Aleksandrov[1, 2], P. Kudryavtsev[1, 2], and B. Hascakir[2*]

[1]LLC "LUKOIL-West Siberia" and Texas A&M,

[2]Texas A&M University

[*]Corresponding author: hascakir@tamu.edu

Abstract

In-situ combustion (ISC), being one of the most successful thermal enhanced oil recovery methods, is highly sensitive to reservoir heterogeneities. In the present study, we investigated the impact of fracture orientation on ISC performance through one dimensional combustion tube experiments on a Canadian bitumen, which possesses good burning characteristics. Two ISC experiments with fractures oriented perpendicular and parallel to the air injection direction were conducted at identical initial and experimental conditions. Fracture formation was visualized with X-ray computed tomography. Temperature profiles, gas compositions, and oil and water production data were recorded continuously during the experiments. Oil upgrading was quantified through viscosity measurements and weight percent of Saturates, Aromatics, Resins, and Asphaltenes (SARA) fractions. SARA fractions were further characterized using Fourier Transform Infrared Spectroscopy (FTIR). Metal content of produced water samples was determined with Inductive Coupled Plasma-Mass Spectroscopy (ICP-MS). Our results show that both fracture types interrupted stable propagation of the combustion front; while the oxygen utilization rate was detected to be lower in the presence of parallel fractures. Thus, parallel fractures led to poorer ISC performance, resulting in lower combustion front velocity and oil production rate compared to perpendicular fractures. Furthermore, the lower oxygen utilization rate increased the interaction between displaced oil and oxygen at lower temperature regions, resulting in Low Temperature Oxidation (LTO) reactions. The produced oil density for parallel fractures was found to be higher than for perpendicular fractures. This difference was attributed to the structural differences in aromatics fraction, mainly determined through FTIR analysis. On the other hand, for both fracture orientations it was observed that