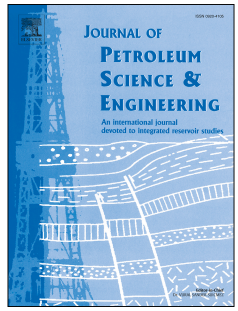
Accepted Manuscript



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PII: S0920-4105(17)30683-6
DOI: 10.1016/j.petrol.2017.08.057
Reference: PETROL 4220

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 8 March 2017
Revised Date: 21 July 2017
Accepted Date: 28 August 2017

Pore Level Investigation of Steam Injection Processes; Visualization of Oil Entrapment and Steam Propagation

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Abstract

The objective of this work is to model the steam injection process and examine the displacement physics at the grain-level. The primary focus is to quantify the oil entrapment behind the swept zone and investigate the pore-level steam propagation and chamber growth. A digital two-dimensional micro-model is reconstructed and fed into a finite element VOF-based solver. The solver is developed by adding necessary source terms to the Navier Stokes equation. The phase change is simulated using the Lee phase change model assuming that mass is transferred in a constant pressure and a quasi-thermo-equilibrium state. For each phase in the multi-region model, the mass conservation, Navier-Stokes momentum, and energy equations under non-isothermal conditions are solved simultaneously. In post-processing results, steam chamber development, vapor condensation over the oil-steam interface, and oil viscosity reduction due to the heat diffusion are demonstrated properly. The simulated oil entrapment behind the swept zone as well as the temperature distribution throughout the medium are in good agreement with the experimental datasets.

1 Introduction

The study of heavy oil recovery is of great interest in Canada, Venezuela, and the United States. This source of energy includes high viscosity, high density (low API number) recourses consisting of high molecular weight hydrocarbons. Total resources of heavy oil in known accumulations are 3,396 billion barrels of original oil in place worldwide (Meyer *et al*., 2007). Because of an extremely high viscosity such as resistance to flow, primary recovery methods are not sufficient for their production. There are different techniques to reduce the oil viscosity so it can be mobilized toward production wells. The available enhanced oil recovery (EOR) methods are classified into thermal, solvent displacements, chemical, polymer flooding, micellar flooding and microbial methods (Hart, 2014). The most widely used EOR technologies are thermal because they reduce the viscosity of heavy oil by several orders of magnitude rapidly. In