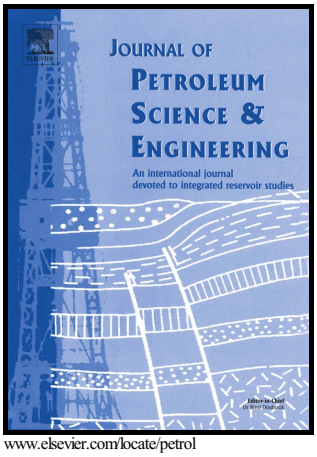

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M. Yakubov, D. Borisov, K. Sinyashin, M. Amerkhanov, R. Khisamov

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Physical Modeling of Ultraviscous Oil Displacement by Using Solvent on a Large Model of Oil Reservoir

M. Yakubov[a,*], D. Borisov[a], K. Sinyashin[a], M. Amerkhanov[b], R. Khisamov[b]

[a]A.E. Arbuzov Institute of Organic and Physical Chemistry of Kazan Scientific Center of Russian Academy of Sciences, Kazan, Russian Federation

[b]PJSC «TATNEFT», Almetyevsk, Russian Federation

[*]Correspondence to: A.E. Arbuzov Institute of Organic and Physical Chemistry of Kazan Scientific Center of Russian Academy of Sciences, Arbuzov st., 8, Kazan, Russian Federation, 420088. yakubovmr@mail.ru

ABSTRACT

As a result of a series of experiments for the physical modeling of oil displacement processes on a large model, specific features of asphaltene sedimentation and immovable residual oil formation in a porous medium were identified. The difference between the residual oil compositions was shown in the zones of dispersive and diffusive oil displacement by solvent. The impact of the solvent composition on the asphaltene concentration in the residual oil in a reservoir model and the cumulative oil recovery was assessed upon the example of the Ashalchinsk field ultra-vicious oil using n-hexane as a basic solvent with toluene and nonylphenol additives.

Keywords: heavy oil; asphaltenes; reservoir modelling; thermal enhanced oil recovery techniques; porous medium

1. Introduction

Currently, the production of heavy oils and bitumens (ultra-viscous oils — UVOs) by borehole methods is primarily based on thermal-stream effect, such as Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD). These technologies are usually challenged by high energy consumption and the need of water fine purification for steam generators. The primary criterion in thermal-stream methods is the availability of fuel resources used for steam generation. To produce one ton of UVO, the standard fuel consumption may reach 300 kg; usually, it is natural gas that is applied as the standard fuel.

The results of pilot projects in Canada (Rassenfoss, 2012) proved the potential of using combined steam stimulation and a solvent to augment the efficiency of heavy oil production. The combined use of solvents with steam will significantly improve the energy efficiency by decreasing the amount of heat required to decrease the bitumen viscosity. This results in decreased OPEX and CO_2 emissions, which is critical from the environmental point of view. Several projects for combined steam and solvent stimulation have been implemented by various companies (Orr, 2009; Boone, 2011; Stark, 2011; Gupta, & Gittins, 2011; Edmunds *et al.*, 2010; Sharma, & Gates, 2010). Usually, light alkanes (C_3-C_6) and their blends, as well as gas condensate, are used as a solvent.

These days, special attention is paid to the development of non-thermal methods of UVO extraction from thin formations where steam assisted gravity drainage is inapplicable. After 20 years of laboratory tests, Imperial Oil Ltd. has been applying Cyclic Solvent Process (CSP) at the Cold Lake within a pilot project. CSP or CSI (Cyclic Solvent Injection) technologies are intended for single wells where solvent injection cycles are alternated with oil extraction in Huff-n-Puff conditions. Recently, a number of process variations has been