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The use of thermal analysis methods for monitoring the development of bitumen reservoirs using thermal recovery technologies

Tatiana Nikolaevna Yusupova[1,2] · Yulia Muratovna Ganeeva[1,2] · Ekaterina Sergeevna Okhotnikova[1,2] · Gennady Vasil'evich Romanov[1]

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Abstract The products obtained from production wells of Ashalchinsk and Mordovo-Karmalsk bitumen fields of the Republic of Tatarstan (Russia) using thermal recovery technologies as well as the core materials recovered from the in situ combustion zone of Mordovo-Karmalsk field were studied with the thermal analysis methods. Using thermal derivatography and calorimetry, it was established that the products obtained from production wells were water–bitumen emulsions, the water content in water–bitumen emulsions was determined, the stability of water–bitumen emulsions was evaluated, and the fractional bitumen composition was characterized. Using thermal derivatography, the organic matter content in the core material and the degree of its transformation in the result of in situ combustion were determined.

Keywords Thermal derivatography · Calorimetry · Water–bitumen emulsion · Stability · Core samples · Organic matter · Degree of organic matter transformation

Introduction

Thermal recovery technologies are generally applicable to heavy, viscous crudes and involve the injection of thermal energy or heat into the reservoir in order to raise the temperature of the oil and reduce its viscosity. Steam (or hot water) injection and in situ combustion are the popular thermal recovery technologies. Three common thermal operations involving steam injection include cyclic steam stimulation (huff and puff), steam flooding and steam-assisted gravity drainage (SAGD). The cyclic steam method, which was developed first and implemented commercially in the 1960s, uses alternate periods of steam injection followed by oil production. However, cyclic steam injection is a less efficient oil recovery method than steamflood because the steam penetrates only a limited radius around the production well. Steamflood technology, introduced in the 1970s, has largely replaced the cyclic steam method. Steamflood technology employs separate steam injection and oil production wells. Steam is injected into the poorly swept portion of the reservoir between the production wells. As the steam penetrates throughout oil reservoir, it facilitates the recovery of a much higher fraction of original oil in place compared with cyclic steam. SAGD is a technology which involves injection of steam into oil reservoir through a vertical or a horizontal producer above horizontal well in the vicinity of reservoir bottom. Heated crude oil and condensates of steam can be produced through the horizontal well at the bottom of the reservoir. In situ combustion involves the injection of air, where the oil is ignited, generates heat internally and also produces combustion gases, which enhance recovery. Although in situ combustion has theoretical attractiveness, it is usually difficult to control and it causes more production operational problems than steam injection processes.

✉ Yulia Muratovna Ganeeva
ganeeva@iopc.ru

[1] A.E. Arbuzov Institute of Organic and Physical Chemistry, Kazan Scientific Center, Russian Academy of Sciences, 8 Arbuzov St., Kazan, Russian Federation 420088

[2] Kazan Federal University, Institute of Geology and Petroleum Technologies, 18 Kremlyovskaya St., Kazan, Russian Federation 420008