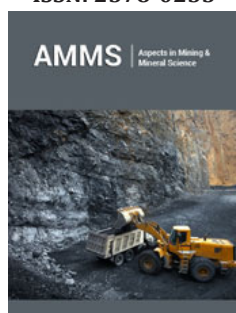


Recent Trends in Development of In-Situ Combustion for Heavy Oil Production and Upgrading

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Opinion

In-situ combustion (ISC) as an Enhanced Oil Recovery method has been applied for 70 years. However, considerable progresses have been made in the last 20 years and they refer to new utilizations of ISC and enlargement of its area of application, as follows:

- a. Application of ISC as a tertiary exploitation method after steam flooding (steam drive)
- b. Application of ISC to deep heavy oil reservoirs of high temperature
- c. Combination of the ISC with horizontal wells as production wells, resulting in the development of the Toe-To-Heel Air Injection (THAI) process

The success beyond the first two mentioned applications, which are enlargement of ISC domain of operation, resides in the full realization that the initiation and operation of ISC in heavy oil reservoirs with higher temperature is easier and almost resembles any gas injection processes for oil exploitation, but with thermal specific characteristics. On the other hand, the success of the THAI process was related to the development of the so-called Short-Distance Oil Displacement (SDOD) processes; both THAI and Steam Assisted Gravity Drainage (SAGD) being SDOD processes. THAI is the first EOR process, which upgrades the heavy oil underground, while recovering it, but without any exterior heat sources; besides upgraded oil, another feature is that significant amounts of hydrogen are contained in the produced gases. With a special completion of the horizontal section of horizontal production well an add-on process to THAI, called CAPRI (Catalytic Upgrading Process In-situ) is under way to be developed and it comes with a second upgrading, while oil flows into the horizontal drain. Results of ISC application as a post-steam drive method for a pilot of 6 adjacent patterns in Romania and a large semi-commercial operation in China showed a very good performance, anticipating a very quick reach of commercial stage in this case.

The main aspects and advantages of ISC operation in deep heavy oil reservoirs are related to a better mechanical integrity of production wells during the process; two commercial operations of his kind indicated that in both cases, the initiation of ISC via the spontaneous ignition and a more robust and stable process derived from this, ensured superior ISC

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performance. Applied in a Direct Line Drive (DLD) configuration, the THAI process has been validated as an in-situ upgraded process by several field pilots in Canada and China. In Canada, the longest THAI piloting in Kerrobert, Saskatchewan Province, has been in operation for 12 years and rich experience was acquired; the partial upgrading of 3-4 points API was achieved, while the viscosity of the in-situ upgraded oil has decreased from 54,000cp to less than 3,000cp (18-fold reduction). In case of the THAI piloting in Athabasca Oil Sands, the percentage of hydrogen in the produced gas was in the range of 2% to 6%, offering a source of hydrogen directly in the field. Applied in a Staggered Line Drive (SLD) configuration, THAI is under way to be validated both technically and economically by a semi-commercial field operation in the Balol Heavy Oil Reservoir of India, which started in 2016, and has been operated in 5 patterns/modules. CAPRI process is in a less advanced development, as no systematic field testing has occurred yet. However, there have been intensive laboratory investigations for more than 8 years in 4 universities. These investigations showed that there is good potential, but many complex aspects related to the robustness of catalysts utilized and ways of operation have to be solved, before a field piloting can be considered. In principle, to

use a fixed-bed catalyst, the fouling of catalyst and its deactivation by asphaltenes, sulfur and metal deposition has to be in-depth investigated. Production of the upgraded oil and hydrogen in the THAI process and other specially tailored ISC processes, for the first time ever in the application of Enhanced Oil Recovery methods, opens the doors for the merging of the Upstream Oil Industry with Downstream Oil Industry, representing a radical step-change in the technology of production and processing of the heavy oils.

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