Laboratory and field scale simulations of in-situ pyrolysis process

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Wide CHLOE's experience in numerical simulations of enhanced oil recovery methods (EOR) and most recently the geological carbon storage processes includes various examples of what can generally be called reactive flow models. For instance, the chemical EOR application study which is still in progress and makes part of our current and nearest future research program comprises numerical analysis of lab-scale tests results of secondary and/or tertiary polymer and alkali-polymer flooding. Several series of coreflooding tests have been successfully analyzed using the same *physical* description of heavy oil(s), polymer(s) and O/W emulsion behavior, the *chemical model* being adapted per different alkali types involved (NaOH, NH_4OH ...). Mention that in this study the *chemically* induced significant modifications of fluid properties resulted in the oil production mostly as heavy-oil-in-water emulsion, did not concern at all the physical state of porous matrix.

Much more diverse in *physical and chemical consequences* has finally been the thermal EOR application example, namely, the simulations at lab and field scale of in-situ upgrading (IU) process based on local reservoir oil heating up and exposition to 380ÂřC for reasonably long time. Like in the above case of AP-flooding the first step of numerical analysis was aimed at development of general enough model using the IU lab test results obtained for different experimental setups. In case of typical Athabasca bitumen the initial IU model has incorporated tens of chemical components and reactions which finally generated quasi-solid residue (pyrobitumen) remaining underground, some amount of produced liquid hydrocarbon mixture and considerable volume of gas (C1-C4). The developed model was capable to represent the phase distribution of pseudo-components, the thermal decomposition (pyrolysis) reactions of bitumen fractions and the generation of gases and solid residue under the laboratory conditions. Furthermore, it has been used on one hand for pre-simulations with a purpose to design future IU experiments, and on the other it was validated via application to IU field-scale test published in literature.

In order to better understand the IU field-scale test results, Shell's Viking (Peace River) pilot was analyzed using developed IU model with rigorously adapted kinetic scheme. The appropriate choice of numerical grid was made and the CPU time was reduced using the adaptive mesh refinement technique. The quality of products, the recovery efficiency and the energy expenses obtained with our model were in good agreement with the field test results. Moreover, the bitumen conversion results (upgraded oil, gas and solid residue) from the experiments were compared to those obtained in the field test. Additional analysis was performed to identify energy efficient configurations and to understand the role of key variables, e.g. heating period and rate or the production pressure, in the general IU upgrading performance. Finally, these results illustrated and quantified the global interplay between energy efficiency and productivity indicators.

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