Simulation Study on New Scale up Methodologies Performance in Chemical Flooding

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Abstract
Chemical flooding is recognized as one of the most complicated process in Enhanced Oil Recovery (EOR) methods, so accurate simulation of chemical flooding requires a detailed understanding of numerous complex mechanisms and model parameters due to highly coupled, nonlinear interactions of many chemical and physical processes involved in chemical process. Enhanced oil recovery methods such as chemical flooding require laboratory analysis of the fluid flow through porous media and the determination of crucial parameters. Afterwards, the results of these studies must be analyzed in a field scale. Regarding the high cost and long time of flooding processes for laboratory models, application of various simulators to simulate these types of studies becomes clear. On the other hand, geological models with more than one million grid blocks are sometimes necessary to capture important geological features such as permeability and porosity distribution associated with an oil reservoir. Unfortunately, simulation of field scale flow using even with more advanced compositional reservoir simulators and current computing power are computationally intensive. In this paper, the effect of grid block size on the performance of Surfactant-Polymer (SP) flooding, and Surfactant (S) flooding for a synthetic layered reservoir is investigated. The simulation study is performed by a three-dimensional, multiphase, multi-component chemical flooding simulator. The effective propagation of the S and SP slug in the reservoir is very important to have high oil recovery efficiency. The larger the grid block size, the greater the surfactant dilution, which in turn dramatically reduces the effectiveness of the process. Simulation results show that the negative effect of using coarse grid simulation is more predominant on SP flooding rather than S flooding. Finally, two new approaches are used as a scale up methodology and their performance in the mentioned processes are explored. In addition, the results show that pseudo lower

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effective salinity approach is more effective to match coarse grid and fine gird simulation results.

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1- Introduction

The depletion of oil reserves and higher oil prices has made Chemical Enhanced Oil Recovery (CEOR) methods more attractive in recent years. Because of geological heterogeneity, unfavorable mobility ratio, and capillary forces, conventional oil recovery methods (including water flooding) leave behind much oil in reservoir, often as much as 70% OOIP (original oil in place). So modeling these processes at large scales requires proper scale-up of both heterogeneity and underlying transport mechanisms. Chemical flooding such as SP flooding or S flooding targets these bypassed oil left after water flood by reducing water mobility and oil/water interfacial tension. The complexity and uncertainty of reservoir characterization make the design and implementation of a robust and effective SP flooding or S flooding be quite challenging. So accurate numerical simulation prior to the filed scale chemical flooding is essential for a successful design and implementation of chemical flooding. Many reservoir simulators have the capability to simulate chemical flooding, such as UTCHEM (UT Austin), MoReS (Shell), Eclipse (Schlumberger), and GPAS (UT Austin). However, they all have some limitations. For instance, Eclipse [Fadili (1)] and MoReS [Farajzadeh (2)] are only able to simulate surfactant/oil/brine Type II (-) behavior. UTCHEM [Delshad (3)] has been developed a very comprehensive chemical EOR model considering complex geochemical reactions and surfactant phase behavior, which imposes expensive computational cost to simulator. Especially, UTCHEM is a single processor simulator and only appropriate for pilot scale simulations. Though GPAS [Najafabadi (4)] is a parallel simulator, it uses the same phase behavior model as UTCHEM, which requires cumbersome match of laboratory phase behavior data to obtain simulation input parameters.

Reservoir characterization techniques have made possible geological reservoir models with multi-million gird blocks populated with permeability, porosity, and fluid saturations. These geological models are often too large to be simulated because of computational limits. These computational limits mean that typical full-field reservoir simulation models are limited to fewer than 1 million cells – at least two orders of magnitude smaller than the geological models and full-field reservoir simulation. Although there have been significant efforts in developing single-phase and two-phase up scaling algorithms, a limited verification of up scaling methods has been performed on full-field basis. In addition to up-scaling techniques, parallel simulation