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Uncertainty Assessment of SAGD Performance Using a Proxy Model Based on Butler's Theory

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Abstract

Steam Assisted Gravity Drainage (SAGD) is an efficient method for thermal recovery of bitumen from the vast reserves available worldwide and particularly from the oil sands in western Canada. Flow simulators are available for predicting SAGD performance and are used to support reservoir management decisions; however, the high computational time associated with the use of such complex flow simulation makes it impractical for all locations especially when reservoir uncertainty and variable operational parameters are included in the making decision process. The use of a simpler analytical model as a proxy for the reservoir simulator is shown to be a feasible alternative to flow simulation. A proxy model based on the Butler's SAGD theory is developed to predict the oil flow rate, cumulative oil production and cumulative steam injection profiles during both: the rising and spreading steam chamber periods for a confined SAGD well pair. Modifying factors are used to fit the proxy to flow simulation results to account for conformance and reservoir heterogeneity among other factors. A critical aspect of the proxy model is a realistic parameterization of geological heterogeneity. Monte Carlo Simulation (MCS) and the proxy model permit an efficient transfer of the uncertainty in reservoir and operational parameters through to performance variables such as oil production and steam oil ratio. An example application for a single well pair showed the efficiency of the methodology in terms of computation time. The results permit improved reservoir management of complex SAGD projects.

Introduction

Current high oil prices are boosting the feasibility of bitumen production projects supported on the availability of tested and succeeded exploitation technology as well as on the vast bitumen reserves available worldwide. An important part of these vast resources are in western Canada. According to the Energy Resources Conservation Board[1], at 2007 the established bitumen reserves in Alberta are 27.45×10^9 m^3 and about 82% is considered recoverable by in-situ methods. The successful application of SAGD process as thermal recovery method is one of the pillars in which Canadian oil industry is supporting the exploitation of the in-situ recoverable bitumen leading to a massive expansion around all Alberta oil's sands.

SAGD is a thermal recovery process based on steam injection coupled to horizontal well technology. Common implementation consists of two horizontal parallel wells, the first drilled near the bottom of the reservoir with the second located at a short distance, typically 5 to 10 m above it. The upper well provides continuous steam supply into the reservoir and the lower one allows the continuous production of bitumen, gas and condensed water. During the SAGD process, the cold oil is essentially immobile; therefore, an initial preheating stage is necessary to create a uniform thermo-hydraulic communication between the well pair. In this start-up period, steam is injected in both wells to preheat the reservoir between the wells. Once mobility has been established, steam is injected continuously into the upper well and rises within the reservoir, developing a steam chamber. The injected steam will reach the chamber interface, heating the surrounding cold oil sand. The heated oil and condensed water will drain by gravity along the chamber-to-reservoir interface to the lower well in which the fluids are continuously produced. The process follows an initial rising period where the steam chamber rises up to the overburden and then the spreading period which is characterized by the lateral growth of the interface along the well pair.

High steam generation costs together with the lower price of bitumen makes the economical feasibility of SAGD projects more sensitive to operational conditions and reservoir variables than conventional light oil projects; consequently less margin of error is available during the reservoir management making decision process. On top of this, the always present uncertainty of reservoir/fluid properties makes the SAGD production performance always uncertain. The natural way to face the