

Speed Up Full-Field SAGD Simulations: Innovative Numerical Tuning Workflow Reduces Run-time by 35-days on a Canadian Full-Field Thermal Heavy Oil Project

Benefits

- Speed up large, full-field simulations, specifically multi-well pad SAGD models
- Properly tuned models maximize the ability to obtain numerically accurate results, with reasonable run time, and saves time in conducting a sensitivity analysis
- Automated workflow to reduce engineering time requirements
- Reduced run time maximizes the throughput and minimizes simulation cycle time
- Using CMOST AI for the sensitivity analysis, makes it less time-consuming for engineers

Operators want to simulate large full-field models because software model sizes have increased, recovery processes are more complex and production continues to ramp up. However, historically engineers working on SAGD projects were limited to starting simulation models with a single well or a single well pad is important.

By employing the latest hardware technology and an innovative workflow for full-field thermal reservoir simulation studies, companies can run both their typical “work-horse” models and larger, more complex models, faster.

Why Simulate a Full-field Model?

Large full-field models provide valuable information on a reservoir’s development potential and interaction between wells. In addition, engineers use the information for reservoir management, operating strategy, flow control device placement and multi-well pad wind down evaluation.

To maximize the value of full-field reservoir simulation, CMG has developed a new and practical workflow for running large full-field models, giving a path for higher performance, shorter run times and efficient use of engineering time.

Three-Step Performance Tuning Workflow



The workflow was applied to a geologically complex, highly heterogeneous 24-well pair SAGD project, located in Alberta, Canada. The model has over 2.52 million active gridblocks and simulated ten-years of production forecast. The application of this workflow improved numerical stability and the run-time of multi-pad SAGD simulation models. Some of the workflow recommendations are specific to thermal processes; however the principles are generally applicable to other types of reservoirs.

Why Tune the Model?

A properly tuned model helps to obtain numerically accurate results sooner. When conducting sensitivity analysis (SA), a tuned model saves a significant amount of run-time and the additional robustness makes SA variations more reliable. This workflow uses sub-models over a shorter simulation time period in order to accelerate the tuning process.

1. Geological Tuning

Geological tuning ensures the reservoir model will run smoothly in STARS™, without impacting geological realism. To run STARS efficiently, it is beneficial to remove unnecessary non-linearities, including unnecessary grid cells or problem grid cells, while maintaining the integrity of the geological description. Maintaining the geological integrity ensures the macro flow properties are modelled correctly without introducing noise into the solution. Simpler is better and never use noise to disguise uncertainty.





2. Numerical Tuning

Numerical tuning is predicated on the principle of balancing run time against additional quality of the solution. Applying numerical tuning can speed up the run time of a geologically -tuned model by a factor of two or better. This workflow ran several hundred cases using CMOST AI, a reservoir engineering tool employing innovative experimental design, sampling and optimization techniques.

The goal of the numerical tuning step is to minimize the global objective function consisting of a weighted average of three local objective functions: run time, material balance error and the number of linear solver errors. It is important to give sufficient weight to both the material balance error and the number of solver failures to prevent achieving a short run time at the expense of accuracy and good convergence.

Finally, 2D cross plots are used to give an idea as to the flatness of the parameter space without running a formal sensitivity analysis. These plots are helpful in assessing the robustness of the parameter sets and to identify if the parameter value selection needs refinement.

3. Dynagrid Tuning

DynaGrid uses coarse cells away from the 'action' and fine cells where rapid changes in reservoir properties are occurring. For the Statoil case, this yielded a 2x performance improvement over the same finely gridded mesh everywhere. DynaGrid dynamically amalgamates cells where no significant changes in dynamic reservoir properties occur from one time step to the next. In addition, DynaGrid dynamically deamalgamates cells where changing reservoir conditions exceed amalgamation thresholds.

Once the regular dataset is tuned and the simulation results are satisfactory, the next step involves investigating and optimizing the dynamic gridding parameters. This approach is similar to numerical tuning except that it targets different parameters and two contrasting objective functions are optimized. For the DynaGrid tuning, representative ranked 2D cross-sections are used to develop dynamic grid refinement parameters for the full 3D model in STARS.

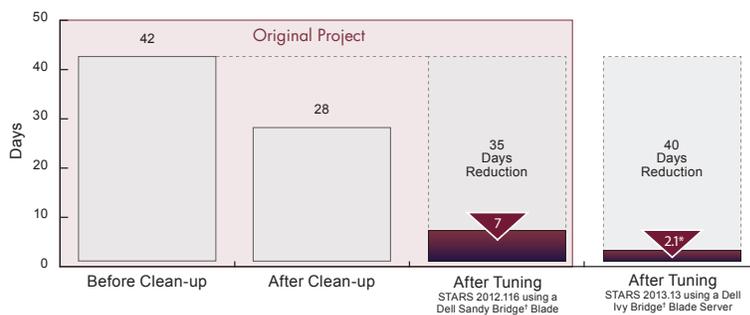
2D cross-sections are applied to run as much of the entire time sequence as possible while maintaining a reasonable time. Applying the 2D cross-sections maximizes the amount of data for history matching using CMOST AI. The final step involves retuning the DynaGrid case for the optimum numerical parameter values. As a result of the larger grid sizes and amalgamation occurring there is some difference between the fine grid properties, which are addressed by retuning for numerical stability.

This case study is based upon SPE 165511 "A New and Practical Workflow for Large Multi-Pad Simulation - a Corner Oil Sands Study". To read the full technical paper, please visit www.onepetro.org.

*The Statoil dataset was re-run using STARS General Release 2013.13 on an Ivy Bridge Dual Socket 12 Core Dell PowerEdge M620 Blade Server, E5-2697v2 2.70GHz, 30M Cache, 8.0 GT/s QPI 128 GB Memory.

Workflow Results

By applying all three steps in the workflow - geological tuning, numerical tuning, dynamic grid tuning - the final run time was 7-days, 2-hours, a six-time speed-up. As a result, the run time is short enough to facilitate simultaneous multiple realization runs using 8 CPUs. This workflow can be easily replicated and most importantly, automated to reduce engineering time requirements.



Contact

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