CMG COMPUTER MODELLING GROUP LTD.

CMOST

Robust Optimization Under Geological Uncertainty

Benefits

- Minimize risk with a well-defined and optimized field development strategy
- Reliably forecast a reservoir's recovery factor under reservoir and operational uncertainty
- Accurately predict probability of reservoir success with reduced risk
- Rigorously analyze geological uncertainty to easily justify a profitable development plan

The value of a company's assets is tied to the fluctuating commodity market. To create certainty within the volatile industry, oil and gas companies follow a detailed field development plan which outlines expected production rates and recovery factor. Reservoir simulation, most often using a single representative geological model, is an industry-wide established step many companies use to create field development plans. However, if the geological model doesn't account for uncertainty, there's a high probability the production rates in the field development plan may be incorrect; thereby adding risk to an entire development strategy.

There is a tendency for reservoir simulation engineers to make the simulation model as accurate as possible by attempting to create a reservoir model and its property distribution using a deterministic approach. This methodology neglects to take reservoir and operational uncertainty into account and could lead to unexpected results when the plan is implemented in the field. For this reason, performing a rigorous optimization workflow, incorporating various sources of uncertainty in the reservoir properties, operational parameters, data measurement uncertainty etc., is essential in field development planning to quantify uncertainty and minimize project risk.

CMOST™, an assisted history matching, optimization and uncertainty tool, has a new Robust Optimization method to account for geological uncertainty and to create a risk-weighted solution to identify the optimum solution. By applying this innovative new workflow and quantifying the uncertainty, companies are able to make better informed decisions, leading to a higher probability of success and profitability.

Nominal Optimization versus Robust Optimization

When companies are designing a field development plan, two optimizations methods are currently used – Nominal and Robust Optimization.

Nominal Optimization uses a single representative reservoir realization – usually a P50 – to perform history match, well location optimization, the injection or production strategy, recovery methods, etc. In this method, the reservoir's geology and rock properties distribution remains unchanged from the chosen geological representation; therefore, assuming it's a good representation of the reservoir conditions. The advantage of Nominal Optimization is the study is conducted quickly and the solution is likely to improve results, as long as the geological properties and distribution are fairly representative of the reservoir. However, any data uncertainty can yield unexpected results in the field.

Robust Optimization solves the issue of data uncertainty by accounting for multiple geological representations, or other uncertain parameters, to identify the optimum results for a field development plan. Robust Optimization considers a range from the worst to the best case geological scenarios, resulting in a development plan that minimizes any surprises when implemented in the field. Sensitivities of parameters such as well location and injection/production strategy are done on multiple geological realizations in an effort to increase the accuracy of the development plan. This rigorous method, although more time-consuming, reduces the risk associated with production forecasting and the development of a field optimization plan.

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When to Apply Robust Optimization

The input data used in reservoir simulation often has uncertainty associated with them. Robust Optimization method helps create a development plan that would be valid for a wide range of reservoir conditions and uncertainty.

It is best to apply Robust Optimization when:

- Field development planning and production forecasting for:
  - Greenfield: lack of measured data; large uncertainty
  - Brownfield: with some production/injection data; somewhat reduced uncertainty.
- As asset with limited reservoir characterization and operational data, E.g. seismic, well logs and/or core data.

Robust Optimization Method

CMOST's Robust Optimization method is a multi-step process that works in conjunction with CMG's reservoir simulators – IMEX™, GEM™ or STARS™. The main advantage of Robust Optimization is that geological uncertainty is accounted for and used to identify one optimal set of operating parameters that globally works for all cases.

Typically, Engineers generate several cases - usually using hundreds of different realizations - and ideally use those realizations to optimize the field development plan and production forecast. However, to shorten project time and the engineer's effort, geological ranking schemes are chosen to reduce the number of realizations used in the study. As a result, a subset of realizations are chosen, most often five representative geological realizations are selected to capture the entire geological uncertainty domain – usually P5, P25, P50, P75 and P95 - based on the probability of occurrence.

Using CMOST, apply the Robust Optimization objective function to identify the optimal set of parameters that will result in the maximum average recovery from all the selected geological realization cases. CMOST will optimize the average Recovery Factor (RF) for a range of chosen realizations instead of a single realization. The resulting RF will show reduced scatter because the optimization algorithm includes both good and poor geological cases; indicating a lower risk and higher probability of success.

Summary

In reservoir optimization, geological uncertainties normally have significant impact on reservoir performance, as a result, the optimal solution obtained based on a single realization (a Nominal Optimization) may deviate significantly from the actual optimum. Consequently, there is a need to use Robust Optimization methodology to take into account the influence of the geological uncertainty. CMOST Robust Optimization is a practical workflow that can significantly reduce computational cost by using a set of representative realizations, while still accounting for the overall geological uncertainties of the reservoir.

Consequently, companies are able to maximize a reservoir's potential by implementing the best recovery method to increase production and achieve the reservoir's full economic value.

To learn how the Robust Optimization workflow has been applied to a Low Salinity Waterflood model, please read the "Robust Optimization under Geological Uncertainty" case study, which is a summary of SPE 173194.

The Robust Optimization workflow will be available to all licensed CMOST users with the 2016 General Release. To learn how to apply the Robust Optimization workflow to your project, please contact **sales@cmgl.ca.**

Contact

For more information please contact **sales@cmgl.ca**

R&D Investment

CMG reinvests 20% annual revenue back into R&D, to further innovation and drive technology forward

Superior Software

CMG delivers easy to use software that provides the most accurate results

Dedicated Support

Experienced technical sales & support personnel, deliver high-quality, timely and personalized customer support

Relevant Training

CMG's industry renowned reservoir software training provides the skills to improve productivity and efficiency