RM03

Evaluating Property Uncertainty in Mature Fields – Demonstration of a Feasible Multiple-Geomodel Approach

S. Kuhlmann* (ConocoPhillips), B. Wendt (ConocoPhillips) & H.J. Yu (ConocoPhillips)

SUMMARY

A mature field with over 30 years of production history constrains uncertainty of the in-place and recoverable volumes. The amount of available static data also provides insight into the intra-dependencies between variables. Honoring dependencies of variables in a stochastic uncertainty study adds complexity but results in realistic models leading into production forecasting and improved economic evaluations.

The workflows used and developed for evaluating the property uncertainty of a Norwegian chalk field will be presented. The focus of the uncertainty study was on maintaining a consistent reservoir description throughout the full modeling cycle; starting from petrophysics and ending with a suite of simulation models that provide a high quality history match without ignoring any of the fundamental underlying principles.

Introduction

Declining production in mature fields can drive the question: is re-development of this field desirable? To make a technically and economically sound decision on hydrocarbon (HC) potential the following questions need to be answered:

- What was the range of original oil in-place (OOIP)?
- Where are the remaining reserves?
- What is the range of recovery with new wells and advanced recovery measures?
- How do the economics of this opportunity compare to other projects?

A field with over 30 years of production history has large volumes of data to constrain uncertainty associated with the answers to these questions. With more reservoir insight it also becomes clearer how the different static reservoir property parameters like porosity, permeability and initial water saturation are interlinked. In an uncertainty study these dependencies need to be maintained to ensure that realistic static and dynamic models are used for economic decision-making.

Method

Building on a deterministic static and dynamic base technical case model (BTC), a stochastic approach was chosen to assess the uncertainty in incremental HC recovery and water production for a re-development scenario centred on water flooding the field in the case study.

To develop uncertainty ranges and probabilistic production profiles, the uncertainty parameters need to be identified and their sensitivity assessed to define key drivers. While aiming to treat uncertainty in the model holistically using an assisted history matching (AHM) approach, it was also necessary to tailor the uncertainty work by minimizing the number of key drivers to keep run-times feasible for probabilistic simulation. In addition it was crucial to define how uncertainty was measured; economic solutions had to factor both recoverable volumes and water production. While parameters might be critical for one aspect they can rank low for the impact on the other.

Parameter screening established that the static reservoir properties: porosity, permeability and water saturation, were highly dependent parameters. To maintain the links between them and to capture the spatial uncertainty component (which for a brown field is often more sensitive than uncertainty in absolute values) a sub-workflow was developed that evaluated petrophysical and geospatial uncertainty prior to the AHM process (**Figure 1**). First porosity uncertainty was assessed. Only parameters identified as sensitive were carried forward in a full uncertainty run with an output of about 500 models. The cases were ranked on OOIP and potential connectivity. Then screening was done to select representative cases where porosity uncertainty could be combined with uncertainty in water saturation and matrix permeability. In this second step the influence of probabilistic petrophysical interpretation was also tested. Again a number of output cases were generated. Another smart selection process captured the range of geological complexity and potential flow behavior of the reservoir within a few discrete geospatial models. Reducing the number of discrete static models in the AHM process significantly reduced simulation run-time.

Figure 1 Sub-workflow property uncertainty.

Structural uncertainty in this field could not be treated as independent parameter. It is linked to property uncertainty via dependency of porosity to the reservoir burial depth and of water saturation to the height above free water level. These uncertainty links were directly implemented in the AHM process together with the uncertainty of other static and dynamic key parameters.

Conclusions

In the integrated uncertainty study it was beneficial to initially address static property uncertainty in a separate workflow and not bring the individual parameters directly into the AHM process. The intra-dependency and spatial uncertainty of these static parameters would have required a huge number of realizations to adequately capture the full distribution of uncertainty and subsequently unrealistic simulation run-times. Instead, a small number of representative static cases were identified, used as a single uncertainty parameter, and combined with all the other key uncertainties into a comprehensive sensitivity and assisted history matching analysis. This method ensured all history matched simulation models were based on realistic geomodels. With a suite of alternative, realistic simulation models of ‘equal quality’ rigorous production forecasting and economic decision-making for future re-development scenarios was enabled.

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