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Improving Quality of Simulation Modeling Using Assisted History Matching Workflows – A Case Study of Zubair Formation

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SUMMARY

In order to obtain a reliable dynamic model, a typical history matching process involves minimizing the difference between measured data and simulated value. In a conventional history matching process, uncertain parameters that are considered to have significant impact on the solution space of the model are manually perturbed in order to minimize the difference. This method is widely used in the industry as it gives the engineers the flexibility to vary parameters based on their judgement and experience. However due to multidimensional nature of the problems in reservoir simulation, manually spanning the range of uncertainty simultaneously becomes unmanageable. Thus Assisted History Matching (AHM) methods are being employed to partially “automate” the process.

Introduction

In order to obtain a reliable dynamic model, a typical history matching process involves minimizing the difference between measured data and simulated value. In a conventional history matching process, uncertain parameters that are considered to have significant impact on the solution space of the model are manually perturbed in order to minimize the difference. This method is widely used in the industry as it gives the engineers the flexibility to vary parameters based on their judgement and experience. However due to multidimensional nature of the problems in reservoir simulation, manually spanning the range of uncertainty simultaneously becomes unmanageable. Thus Assisted History Matching (AHM) methods are being employed to partially "automate" the process.

Project Background

The goal of this project was to explore the possibility of non-uniqueness of the history matching solution using AHM workflow. Thus the scope of this work was to execute a workflow that explores the parameter space to obtain one or more calibrated reservoir models. The case study being presented in this paper demonstrated an improvement in the quality of the history match when using AHM workflow as compared to the manual history matching process. Improvement in quality of the match (at field level) was quantitatively assessed by comparing the global and partial objective functions. It was also found to be easier to manage and analyse simulation results especially when multiple variables were altered simultaneously.

The case study presented here is a Zubair formation field located in the southern Iraq, 20 km from Basrah city. The structure of the Zubair Field is a relatively gentle anticline oriented NNW – SSE, approximately 60 km long and 10-15 km wide. The field comprises of two main producing reservoirs – the Mishrif carbonate, and the Zubair sandstone that includes three reservoirs. It is a matured oil field, discovered in 1949 and has been in operation since 1951. It is an active waterflood operation with ~10-15% of total wells as injectors. There are more than 200 wells in the field.

Workflow

Geo-screening: In the conventional history matching process, a geological model was built for each of the producing reservoirs. A 3D black oil simulation model was built based on the geological model. Unlike in the conventional method, in the workflow being presented in this paper, six additional equiprobable geological models were built varying the static uncertainty parameters that had significant impact on the field recovery. Black oil models were simulated based on each of the geological model. One of the geological models was then chosen as the base geomodel by comparing the objective functions.

Sensitivity analysis: In the conventional method, history match was achieved starting from expected values of different parameters and made iterative modifications to achieve a reasonable match of the actual field measurements, *e.g.*, rates, water cut, GOR, pressure, etc. This was called the 'Reference' model. Instead in the proposed approach a more extensive range of dynamic parameters such as fault transmissibility, aquifer strength, PVT properties, end point saturations and permeability, and anisotropy were chosen for sensitivity analysis. Relative significance of these parameters on the quality of the history match was determined and then optimized through AHM algorithms.

History matching: In the AHM workflow objective values were minimized using Evolution strategy optimizer. Thus the simulation process resulted in generations of non-unique solutions. On the contrary, in a conventional history matching approach the history matched model is considered to be the single best representation of the reservoir which is a simplified assumption in most cases.

Objective functions and history matching workflows were run using advanced reservoir simulation commercially available software applications. Flow diagram shown in Figure 1 describes each of the above steps in further detail.

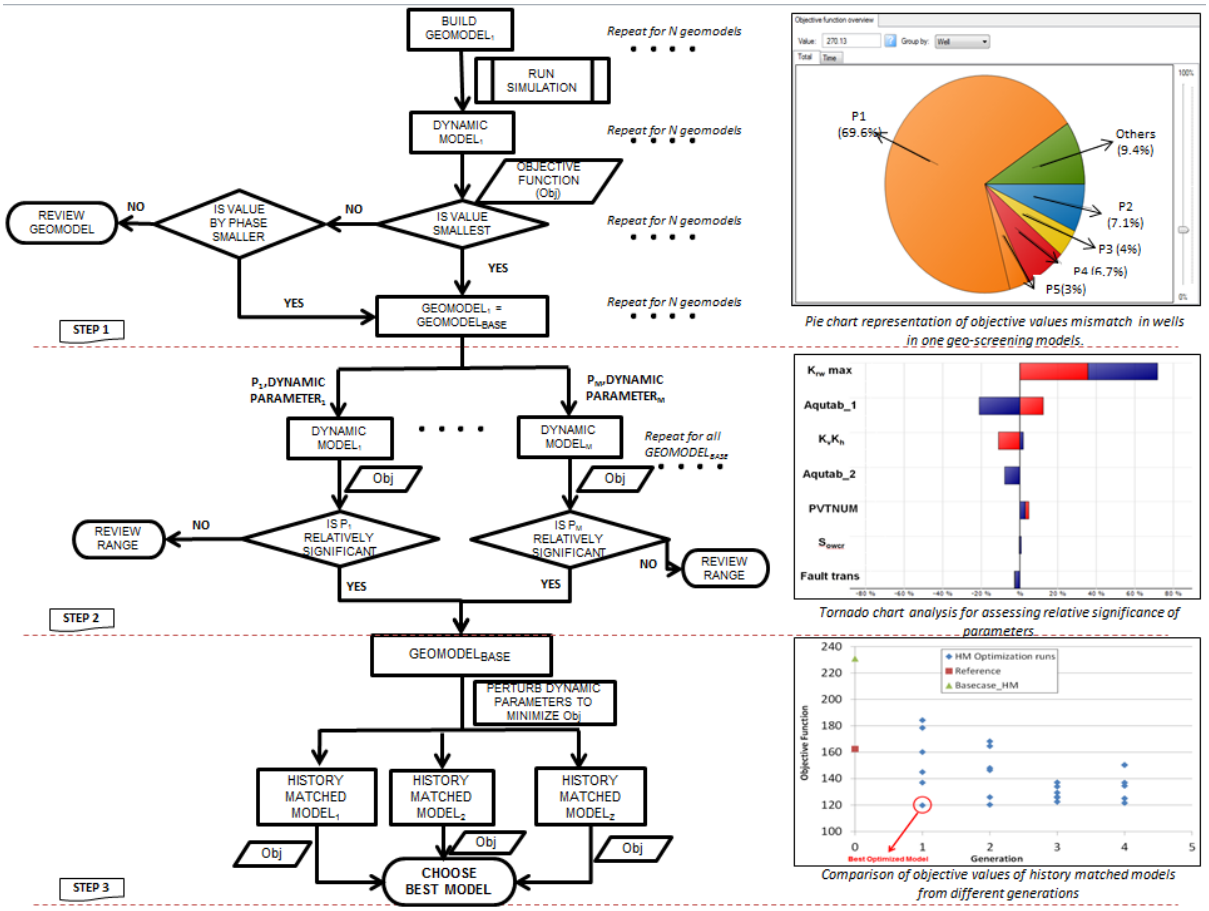

Figure 1 *is a generalized flow diagram of the workflow used in this project. Three main steps in the workflow were: Step 1: Geo-screening – Global and partial objective functions were compared to select the 'best' geomodel. Step 2: Sensitivity Analysis - Objective values were compared using Tornado chart to determine the relative significance of the parameters. Step 3: History Matching – Dynamic parameters were optimized to minimize objective values.*

Conclusions

The workflow was applied to all the three reservoir models independently. The following conclusions were drawn:

- In Zubair sandstone reservoir models, the history matched models obtained from the proposed approach was better than the history matched model obtained from the conventional method.
- The proposed workflow resulted in a set of optimised models that had similar history matching quality but were obtained from different combinations of the dynamic parameters.
- In case of the Mishrif carbonate reservoir model conventional approach resulted in a better quality of history match than through the proposed methodology. This indicated that the parameter space for the optimisation workflow needed to be revisited.

References

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