Manual versus Software Assisted History Matching Advantages and Limitations

Shawket G. Ghedan[1], Adrian Gibson[2], Ilhan Sener[2], Ralf Schulze-Riegert[3], Ozgur Gunal[1], and Alex Diab[3]

[1]The Petroleum Institute, PO Box 2533, Abu Dhabi, UAE
[2]Abu Dhabi Company for Onshore Oil Operations (ADCO), Abu Dhabi, UAE
[3]Scandpower Petroleum Technology, Hamburg, Germany
sghedan@pi.ac.ae

1. Introduction

History matching is defined as the process of reconciling geologic models to the dynamic response of the reservoir. The main purpose of history matching is building a numerical simulation model which is consistent with the entire available reservoir data, i.e. geological, petrophysical and Special Core Analysis (SCAL) data as well as production data including field and well pressure, flow rates, water cuts and gas oil ratios.

Some known giant petroleum fields in the world are carbonate reservoirs characterized by a high level of heterogeneity. This level of heterogeneity necessitates the understanding of reservoir uncertainties in all levels of the reservoir modeling process including: data acquisition, geological static modeling and dynamic simulation modeling. Manual history matching of the simulation of these kinds of reservoirs often fails to cover important reservoir uncertainties. Geological models derived from static data, such as geological, well log, core and seismic data, often fail to reproduce the reservoir production history [1].

In order to obtain an acceptable description of the reservoir by history matching, many different simulation runs in completely different regions of the search space must be performed [2]. In order to capture reservoir model uncertainties within the range of model parameter uncertainties, a variety of models should be generated. They will not be distinguishable with respect to the reproduction of history data but may deliver different predictions of future reservoir performance [3]. The manual history matching process often tunes a limited set of parameters to reach to only one acceptable non-unique history matched model. In addition to this serious limitation, manual history matching is time consuming, and faces a real challenge in terms of keeping track of the model response to parameter changes and their combined effect on the field, sub-reservoir and wells levels.

2. Key Features

This paper presents a case study using a Multipurpose Environment for Parallel Optimization with application to assisted History Matching. Evolutionary Algorithms and deterministic optimization schemes are integrated into a workflow controlling a large number of parallel reservoir simulations to history match an inverted 5-spot waterflood pattern that had been subject to an extensive program of reservoir pressure and water saturation monitoring. Results are analyzed and compared to traditional History Matching to identify the potential added valued and increased efficiency.

The quality of the manual history match was reproduced for pressure data and significantly improved for saturation data. The resulting model exhibits better forward modeling characteristics defined by matching of some blind test data. Due to highly constraining boundary conditions defined by pressure and saturation data, it was not possible to generate multiple solutions to this specific problem. Within the given constraints, the model tuning parameters had to be close to the values of the reference case to be able to match and wells levels.

The software assisted history matching process improved the quality of the match with less time and effort than the manual method. A lesson learned process is discussed focusing on the engineer acquiring more information and improving the understanding of reservoir uncertainties and the reservoir model behavior. With these techniques, turnaround times for creating new models and updating old models has been significantly reduced.

3. Conclusions

1) The quality of the Manual History Match was reproduced and improved for the TDT Sw profile matching.
2) This sector model is very constrained by intense real pressure and water saturation data; such situation eliminates the possibility of multiple solutions to this history matching problem.

3) The prediction of blind history data proved to give better results and history matching quality than the manual history match.
4) The transparency of the project was improved significantly by establishing an audit trail. This allowed detailed review processes for all project phases.

4. References and Bibliography

1. He, Z., Datta-Gupta, A., and Yoon, S., 2001, "Streamline-based Production Data Integration Under Changing Field Conditions," Paper SPE 71333, presented at the SPE ATCE, New Orleans, September 30 - October 3.
2. Schulze-Riegert, R.W., Axmann, J.K., Haase, O., Rian, D.T., and Yoi, Y.L, 2002, "Evolutionary Algorithms Applied to History Matching of Complex Reservoirs," SPE Reservoir Evaluation and Monitoring, April.
3. Schluze-Riegert, R.W., Diab, A., and Haase, O., 2004, "Streamline-Based History Matching with Application of Global Optimization Techniques," Presented at the DGMK Spring Conference, Celle, Germany, April.

Author Biographies

Dr. Shawket G. Ghedan is an Associate Professor of Petroleum Engineering at The Petroleum Institute (PI), Abu Dhabi, UAE.

Mr. Adrian Gibson is a Senior Reservoir Engineer with Abu Dhabi Company for Onshore Oil Operations (ADCO), UAE.

Mr. Ilhan Sener is a reservoir engineering expert with Abu Dhabi Company for Onshore Oil Operations (ADCO), UAE.

Mr. Ralf Schulze-Riegert is a Principal Consultant with Scandpower Petroleum Technology, Germany.

Mr. Ozgur Gunal is a Senior IT Engineer at the PI.

Mr. Alex Diab is a Reservoir Engineer with Scandpower Petroleum Technology, Germany.