Integrated Mature Field Management System from Rapid Production Update to History Matching

Introduction

Mature field management requires reservoir engineers to frequently update dynamic reservoir models with latest production data and repeat history matching process. The lack of tools to standardize and automate simulation model update makes the process tedious (Tayeb Y. et al. 2021). Repetitively assimilating new production data into reservoir models, preceded by a mundane data quality control and followed by history match quality re-assessment is still done manually in many cases and requires significant effort. An integrated mature field management workflow has been developed to provide a quick assimilation of new production data from a database into reservoir models and advanced tools for history matching quality analysis.

Method and Theory

The system comprises of three parts: Data gathering and QC, Dynamic model update and History match quality check.

- Data gathering and QC
  
  Production data repository is firstly linked with reservoir modelling platform to acquire latest production information. Database properties such as fluid rates, ratios, uptimes, monthly volumes and well pressures (static, BHP, THP) are mapped by users to those of a simulation model. As new production data is gathered, it needs to be evaluated as to quality and consistency before being integrated into a simulation model. Flexibility is provided for users to remove invalid properties before assimilation process. Additionally, the reported dates are controlled for duplication. Inconsistent data is highlighted and cleaned up. An innovative algorithm has been introduced to solve the puzzle when well names in the production database are different from those in the modelling platform. The algorithm involves mapping wells based on production rate, and the wells are considered matching if more than 50% of their data is identical. An additional QC step can be performed to compare the contents of the production database with the historical data already used in the dynamic model to ensure their consistency.

- Dynamic model update
  
  Next step is to assimilate validated data into the simulation model. Latest observed data is imported from the last date of historical data. If observed surveillance data such as RFT/RST/PLT logs are available, they can be incorporated to the workflow. Once provided, the program edits the simulation model to request respective simulation results at the same dates for mismatch evaluation between the simulation and the measured logs. The updated simulation case is automatically run after the importing, and new simulation results are then available for the next history match quality check process.

- History match quality check
  
  The history matching quality assessment is based on production/injection rates, cumulative volumes, ratios (i.e. GOR, water cut), water breakthrough time and pressures. If surveillance data logs (RFT, RST and PLT) have been provided, then respective pressure, saturations and flow rates are also assessed. Comparing against predefined KPIs’ thresholds, the match is rated as “good”, “acceptable”, or “needs improvement”. A notion of weight function is also introduced to allow reducing the contribution of certain points in the mismatch calculation for selected wells and parameters.
The resulting information is presented in a comprehensive dashboard with tables, pie charts, and bubble maps.

Examples

A synthetic model starts with two production wells and two injection wells is used to demonstrate the process and compare it with traditional workflow for efficiency.

![Figure 1. The synthetic model with two producers: PROD_02_dual and PROD_01, two injectors: INJ_01 and INJ_02](image_url)

The base simulation case contains production history data from Jan 1st 2016 to Jan 1st 2017.

Observed production data update process

Additional observed data from Jan 2nd 2017 to Jan 1st 2020, for the existing two producers and two injectors is recorded and stored under Oil Field Management data repository. A new horizontal well Horiz1 and a new producer PROD_02 are drilled in the new period.

Observed RFT log data is also recorded periodically in the new dates. Once included in the updated process, update simulation case will generate simulated RFT data on corresponding dates.

After Oil Field Management data is linked to the base simulation case, and before updating the production data with additional observed data. Quality check of import data is performed. Invalid data points, like negative production rate or negative bottom hole pressure, are identified and removed. With the data quality checked, and corresponding production data and wells mapped correctly between data repository and the base simulation case platform, the update is done with one click. The updated case is then run to the last point of new dates.
History matching quality check

The updated history matched case is then passed to the next stage for history matching quality analysis. Mismatch calculation can be based on either average relative error or average absolute error, depending on different properties. The equation for average relative error in rates is:

$$Rate_{mismatch} = \frac{\sum_i^n w_i |Rate_{obsi} - Rate_{simi}|}{\sum_i^n w_i Rate_{obsi}} \times 100$$

Threshold values for good, acceptable, and need improvement categories are defined. The same KPI definition can be defined for both production data and surveillance log data. Weight function for oil production rate under well PROD_01 is added to the mismatch calculation process.

When the workflow is set up and run, mismatch statistics is presented in tabular format, pie charts, and bubble maps:

Table 1 summarize mismatch results for each production property for individual wells. They are color-coded based on defined threshold values. The overall history match quality for all four producers need improvements while the match quality for two injectors are acceptable.

The mismatch results are analyzed from the field level too. A pie chart is generated for each production property. It indicates number of wells falls into each category. The first pie chart in Figure 3 shows two producers among total four production wells have a good history match in oil production rate, while the rest two producers have a oil rate history match that needs to be improved.
Figure 3. Pie charts indicating number of total wells falls into each category for each production property

Figure 4 is the oil production rate mismatch results in bubble maps. Both quantitative map and qualitative map are generated for each property. The quantitative maps reflect average relative error for each well, while the qualitative maps indicate history match quality category: “good”, “acceptable”, and “need improvement”.

Figure 4. Left: quantitative bubble map of oil production rate mismatch results; Right: qualitative bubble map of oil production rate mismatch results

Conclusions

Examples are presented in this paper to contrast the traditional approach with this improved workflow. The automatic workflow significantly improves the effort of the whole model update and history match quality assessment process from days to hours. The more cycles of the production data update and history matching re-assessment, the more efficient the process is. It helps to keep the model evergreen and increasing the confidence in the mature field management.

References