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History Matching Protocol Using Artificial Neural Network

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Abstract

Modeling complex hydrocarbon reservoir systems is a challenging process that involves history matching of actual production and pressure data and subsequently forecasting reservoir behaviour. History matching is done through systematic modifications of the numerical reservoir models in order to reproduce actual production rates and pressure profiles.

The most common conventional approach in history matching is the tedious and time-consuming 'trial and error', which involves manual, in some cases random, and inconsistent, modifications to the parameters of the reservoir model until the simulated results match with acceptable accuracy the actual reported production and pressure data. To ensure uniqueness of the history matched reservoir model, numerical optimization and geological consistency must be observed in the modification process.

Automated history matching methods were introduced to overcome the manual history matching drawbacks. Automated methods are faster techniques for history matching compared to manual method. Larger number of parameters can be dealt with as well. However, in large and complex models, the automated techniques suffer from some challenges. The major challenges are: the inflexibility to incorporate into existing simulators, large number of runs required and convergence issues for multidimensional problems. To overcome some of these issues, new techniques like Artificial Neural Network (ANN) and Ensemble Kalamn Filter (EnKF) were introduced.

In this work, a history match protocol involving artificial neural network (ANN) is developed to predict accurate reservoir model parameters. The protocol consists of four main stages: selection of target parameters and ranges, simulation to obtain ANN inputs (pressure and/or production), ANN training and validation, and finally prediction of reservoir parameters for history match. The protocol was tested with a real gas reservoir with limited production data. The target parameters tested were: porosity and permeability multipliers, formation compressibility, and Corey exponents for water and gas.

Several network configurations and components were tested to investigate their effect on ANN performance. The prediction error was different for each of the target parameters. The highest prediction error was associated with compressibility values and vertical permeability multipliers. Whereas, Corey exponents prediction error was the lowest compared to the other parameters.

The final optimized ANN was used to predict the simulation parameters for better history match in a dry gas carbonate reservoir. The resulting history match is excellent and showed that ANN is a robust tool for history match.