Efficient And Accurate Reservoir History Matching Workflow - An Application In Fractured Reservoirs Considering Complex Physics

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Abstract

Objectives/Scope: History matching is an essential technique for calibrating the simulation model and assessing the unknown uncertainty parameters in fractured reservoirs. However, the history matching process is often challenging due to the subsurface uncertainties and non-uniqueness solutions. This work proposes a novel workflow to perform the history-matching process using Bayesian inversion assisted by Long-Short Term Memory (LSTM) surrogate.

Methods, Procedures, Process: There are five steps within our workflow. Step 1: Identifying uncertainty parameters using the Global Sensitivity Analysis (GSA), including the injection rate, porosity, capillary pressure, oil viscosity, density, relative permeability, etc. These parameters’ initial range and distribution are also determined based on prior knowledge. Step 2: The Latin Hypercube sampling (LHS) generates the training and testing dataset. Using the generated datasets, a discrete fracture model (DFM) generates the pressure response in different producers. Step 3: The LSTM model is constructed to map the relationship between the input and output, in which the Bayesian optimization is utilized to tune the hyperparameters automatically. Step 4: We use Bayesian inversion to inverse the uncertainty parameters based on real-field pressure responses, in which the MCMC method is used to perform the Bayesian inversion computation. Step 5: We feed the inversed uncertainty parameters into the simulation model to produce the pressure responses. If the mismatch is minor enough, we claim the uncertainty parameters’ inversion is accurate. Otherwise, we need to check the accuracy of the LSTM surrogate model.

Results, Observations, Conclusions: We demonstrate the proposed workflow using a 3D fractured reservoir modified from SPE 10th model by adding multiple fractures into it, in which different physical processes, including the capillary, viscous, and gravity effects, are considered. Results show that the proposed Bayesian inversion coupled with the LSTM method can accurately capture the uncertainty parameters with narrow subsurface uncertainties. The difference between the real and inverse pressure response is also neglectable. We then compare its superiority with other surrogate-assisted Bayesian inversions, such as kriging, support vector machine, and polynomial chaos expansion, and the proposed method achieves the best performance. The Bayesian inversion assisted by LSTM outperformed other models owing to its capability to process time-series information.
**Novel/Additive Information:** We propose a Bayesian inversion assisted by the LSTM history matching method for the inversion of uncertainty parameters in fractured reservoirs considering complex physics and demonstrate its accuracy and robustness compared with other models. The proposed model offers an efficient and accurate alternative to the traditional methods for history matching in fractured reservoirs that can be readily implemented in real-field applications.