Application of a Physics-embedded Machine Learning Workflow to Manage and Optimize Operations of a Large Waterflood Field

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Abstract

The paper describes the process of modeling a large waterflood field located in Montana, USA, using a workflow that creates a predictive model using production and injection historical data to infer petrophysical parameters; modeling time is significantly reduced while the methodology honors reservoir physics at all times. Data from 2010 was used to create a layered model which was later used to proactively manage the field by implementing different surveillance and forecasting workflows as well as generating the Pareto front and selecting an optimum target scenario to increase production by redistribution of water injection.

Creating the predictive model implies two steps: training the physics-embedded ML to infer the petrophysical parameters using early production and injection data; the training is stopped at one point and the model is asked to "predict" historical production and injection from that point onwards to validate its predictive capacity. This first step is called "Fit" and once completed successfully a set of petrophysical parameters is obtained and used in the next step -"Full Fit"- where the full data set (except the last few times steps used to validate predictivity) is used to train the model and get it ready to predict.

Building a predictive model was achieved in less than 6 weeks and once obtained, forecast scenarios can be run in minutes. Some of these scenarios included evaluating the impact of injection changes or closures, ranking injectors by order of importance, evluate the impact of reactivation of inactive wells and finally, run the model thousands of times to find the Pareto Front -efficienct frontier- and find the optimum injection strategy that maximizes production. An optimized scenario was implemented in the field and the results monitored over time proving the predictive nature of the model and the application of the technology.