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Almaraghi, B., Etienam, C., Villegas, R.

A coupled viscosity estimation and reservoir simulation for ensemble based production optimisation

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Abstract

In this paper we carry out a full field Reservoir calibration and optimisation scenario, coupling molecular interactions and ensemble based optimisation techniques. We use the friction theory model to estimate the viscosity, taking into account the molecular interactions and integrating the results in Reservoir simulation using the equation of state. Model calibration is achieved with the Ensemble Smoother with Multiple Data Assimilation (ES-MDA). Further, we then optimise the calibrated model, focusing on Enhanced Oil recovery technique, with steam injection, utilising the Ensemble based Production Optimisation method (EnOPT). The Hydrocarbons viscosity was estimated using the friction theory, which utilises the attraction and repulsion parameters in a Van Der Waals type equation of state and the concept behind Amontons Coulomb friction laws. The molecular interactions are taken into account in understanding the fluid viscosity behaviour. The link is signified between the molecular interactions and their effect on the velocity between the hydrocarbon fluid layers that are responsible for the resistance to flow. The uncertainty in the estimated viscosity could be narrowed by using Bayesian statistic techniques to match the chosen reservoir parameters with the mean historical data using the Ensemble Smoother with Multiple Data Assimilation (ES-MDA). The Enhanced Oil Recovery technique was chosen to be steam injection in order to reduce the oil viscosity by raising the reservoir temperature without maximising the overall cost. The Net Present Value (NPV) was maximised by using an ensemble based optimisation technique (EnOPT), where the controls of steam injection temperature and two producers bottom hole pressure were the adjusted parameters. The viscosity of a heavy oil required additional recovery techniques to increase the driving force for the production. The heavy oil viscosity decreases with increasing temperature due to the increase in kinetic energy of the molecules that weakens the attraction force and the increases in repulsion between them. The initial mean NPV of the generated 100 realisations of the chosen adjusted parameters was found to be approximately $1,500,000. The mean NPV of the realisations after optimisation was found to be $3,440,056. This increase in NPV was due to the increase in oil production rate, the main parameter influencing the increase in NPV was the cost and amount of oil produced, bearing in mind the water treatment and steam cost. The novelty in this study is a coupling of molecular scale simulation (friction theory) with Reservoir Simulation (by means of the Peng-Robinson Equation of state), which estimates the main physical parameters of reservoir systems and also adequately accounts for the intermolecular forces. We also calibrate the synthetic reservoir model with the ES-MDA infused with EnOPT for realistic model production optimisation. © 2019, Society of Petroleum Engineers.

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