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Multiphase Flow Effects on a Physics-Based Shale Reservoir Production Forecasting Model: A Global Sensitivity Analysis

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The generalized physics-based scaling curve method proposed by Patzek et al. (2013) is an excellent alternative to the decline curve methods that forecast gas production from shale reservoirs. However, it still neglects the multiphase flow effects and may lead to unreliable hydrocarbon production prediction from mudrock reservoirs. In this study, we perform a global sensitivity analysis using a compositional reservoir simulator to analyze the sensitivity of the scaling factors describing the physics-based method to multiphase flow effects varying selected input factors. We built a conceptual reservoir model of a typical, hydraulically fractured shale condensate gas well using a commercial reservoir simulator. We select the fluid input factors and their range of possible values over which we analyze the scaling curve. We perform a space-filling design using the MaxiMin Latin Hypercube sampling method. We run our simulation tests and estimate the scaling parameters: characteristic time of pressure interference between neighboring hydraulic fractures (τ) and hydrocarbon mass in place in the stimulated reservoir volume ($\mathcal{M}_{SRV}$). We then calibrate a surrogate model to map the relationship between the multiphase flow properties and the scaling parameters using Bayesian optimization. Finally, we identify the key parameters affecting the shale condensate gas mudrock plays forecasting using global sensitivity analysis ("Sobol" indices). Our results show the relative contribution of the multiphase flow input factors of the reservoir simulator to the variance of the physics-based curve scaling parameters. We demonstrate the importance of reservoir permeability, initial condensate/gas ratio (CGR), initial reservoir pressure, wet-gas phase behavior, and hydraulic fracture spacing in the variations of $\mathcal{M}$ and τ. We show that the mudrock ultimate recovery factor (EUR) prediction when the condensate saturation around the wellbore is below a critical saturation may be accurately estimated using the single-phase solution. Finally, we highlight the limitations of using the single-phase physics-based scaling curve method to forecast condensate gas production from low-permeability reservoirs.

Participation

In-Person

References

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