A New Approach to Modeling Produciton Decline in Unconventional Formations

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Abstract

Most decline curve methods have two main limitations; the model parameters as a rule are not functions of reservoir parameters and may yield unrealistic (nonphysical) values of expected ultimate recovery (EUR) because boundary-dominated flow may not develop in unconventional reservoirs. Over the the past few years, several empirical models have emerged to address the second limitation, but they are challenged by the time to transition from infinite-acting flow period to the boundary-dominated flow flow. In this study, we performed statistical and model-based analysis of production data from hydraulically fractured horizontal oil wells and present a method to mitigate some of the limitations highlighted above.

The production data were carefully analyzed to identify the flow regimes and understand the overall decline behavior. Following this step, we performed model-based analysis using the parallel-flow model (sum of exponential terms), and the logistic-growth model. After the model-based analysis, the model parameters were analyzed statistically and cross plotted against available reservoir and well completion parameters. Based on the conclusion from the cross-plots and statistical analysis, we used design of experiments (DoE) and numerical-reservoir simulations to develop functions that relate the model parameters and reservoir/well completion properties.

Results from this work indicate that the production characteristics from these wells are highly variable. In addition, the parallel-flow model indicates that there are at least two to three different time domains in the production behavior and that they are not the result of operational changes, such as well shut-in or operating pressure changes at the surface. All the models used in this study provide very good fits to the data and all provide realistic estimates of EUR. The cross-plots of model parameters and some reservoir/well completion properties indicate that there is some relationship between them, which we developed using DoE and flow simulations. We have also shown how these models can be applied to obtain realistic estimates of EUR from early-time production data in unconventional oil reservoirs.