Gas-Lift Optimization Using Proxy Functions in Reservoir Simulation

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Abstract
Artificial lift by means of gas injection into production wells or risers is frequently used to increase hydrocarbon production, especially when reservoir pressure declines. We propose an efficient optimization scheme that finds the optimal distribution of the available gas-lift gas to maximize a benefit function subject to surface pipeline network rate and pressure constraints. This procedure is formulated as a nonlinearly constrained optimization problem solved by the Generalized Reduced Gradient (GRG) method. The values of benefit function, constraint functions, and derivatives needed for optimization can be evaluated through two methods. The first method repeatedly solves the full-network equations using Newton iteration, which takes into account the flow interactions among wells; however, this method can be computationally expensive. The second, and more efficient, method constructs a set of proxy functions that approximates the benefit function and constraints as functions of gas-lift rates. They are obtained by solving part of the network that consists of a gas-lifted well or riser, assuming a stable pressure at the terminal node where the partial network is decoupled from the rest of the network, and are used to inexpensively evaluate the benefit function, constraints, and necessary derivatives for the optimizer. A procedure to predict the proxy functions based on previous values can be used to reduce the number of partial network solves, and the partial network solution has been parallelized for faster simulation. The proposed methods are implemented within a general-purpose black-oil and compositional reservoir simulator and have been applied to real-field cases.