Waterflood Recovery Optimization Using Intelligent Wells and Decision Analysis

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Abstract
The many critical decisions in a waterflood recovery process range from well number, architecture, and completion configuration to scheduling and facilities capacity planning. Project success is also affected by subsurface uncertainties, such as reservoir heterogeneity and compartmentalization, as well as surface events including equipment uptime and availability. Managing the complexities of a waterflood recovery is traditionally a sequential and intermittent process in terms of data acquisition, modeling, and workflows. However, traditional project planning, execution, and monitoring may help an operator reach production targets and budgets, but these activities do not necessarily align technical and business goals to create a comprehensive development plan that increases the probability of optimal business success.

This paper describes a process to maximize long-term economic return by optimizing key decisions, such as well number, placement, and use of intelligent wells and operating schedules, as well as evaluating surface capacity parameters, such as export pipeline diameter and pump inlet pressure. An integrated asset model (IAM) simultaneously simulates the reservoir flow, wells, and facilities, and calculates the economics associated with each potential decision scenario. An automated optimization workflow is presented as an efficient procedure to handle a large number of decisions. A well-known industry waterflood case study is discussed in the paper. A development plan that includes processes for maximizing oil recovery and economic return by implementing intelligent-well operational procedures is presented.

The results from this work for the case examples presented show that the number and location of the wells are more significant factors in the success of the field development plan than the selection of export pipeline diameter or pump inlet pressure. The optimum selection of well number, location, and producer to injector ratio could lead to an increase of 136%, when compared to the optimized primary recovery case. In the secondary recovery example, a proactive operating scheduling of intelligent well valves improved the waterflood project value by 130% with respect to the case with no intelligent completion; this was achieved by the efficient reduction in produced (~9%) and injected (~8%) water, and the increase of produced oil (~3%).

Applications of this workflow and integration by professionals from multiple surface and subsurface disciplines provide a means of minimizing the risk of investment and setting optimal surface parameters that maximize production while reducing capital and operating costs. In this way, the return on investment of the project is optimized. The decision framework presented may be applied in any type of hydrocarbon field, from early to mature development, and may be extended to other important decision variables, including the selection of the reservoir recovery process and market strategy.