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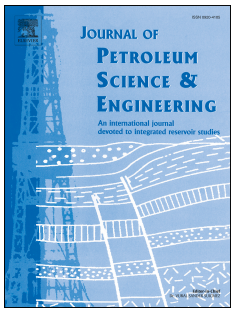

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Determination of Vertical/Horizontal Well Type from Generalized Field Development Optimization

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Field development planning entails determination of the optimal number of wells (horizontal/vertical), well types (producer/injector), well locations, and well controls. The numerous variables to be estimated and the reservoir geological uncertainty complicate the problem of determining the optimal development plan. The improvements in computational science have advanced the use of automated optimization for field development decisions.

In this paper, we present a generalized field development optimization methodology for estimating vertical and horizontal well-types in developing a hydrocarbon reservoir. Two approaches for the generalized field development optimization are presented. One approach is based on the well control zonation (WCZ) procedure; the other is based on the mixed integer non-linear programming (MINLP) procedure. In the WCZ procedure, five zones were identified, each signifying a region of either horizontal injection wells, vertical injection wells, no wells, vertical production wells or horizontal production wells. In the MINLP approach, separate variables were defined for the determination of the well type. Additionally, we present an efficient method to constrain the minimum well spacing of the horizontal and vertical wells to predetermined parameters. The aim was to optimize the number of wells, the well types, the well locations and the well controls (production rates). These operational variables were estimated simultaneously. Particle swarm optimization (PSO) algorithm was used as an optimizer to determine the optimal parameter values.

The WCZ and MINLP approaches were tested with two examples to determine which methodology was more effective. The results indicated that both methods could successfully determine the optimal parameters while satisfying the spacing constraints imposed by the user. The comparison of the results showed that the WCZ approach was more effective than the MINLP approach.

1 Introduction

Well management optimization is a field planning task that can improve reservoir performance and the economic value of oil and gas field development. Conventionally, reservoir management teams devise field development methods through sensitivity studies. The oil and gas industry is currently shifting from using traditional/intuition-based optimization to using automated optimization algorithms. Field development management requires judicious deployment of resources to ensure maximum return on investment. The crucial parameters to consider in field development include the type of wells (horizontal or vertical wells), the number of wells (both the number of injectors and producers), the well locations, and the rate at which the wells produce. Recently, there has been a gradual shift from a traditional well management approach, i.e., the use of reservoir quality maps (to identify sweet spots) to direct the appropriate location of infill wells, towards the use of optimization software. However, the use of quality maps does not guarantee long term profitability of the project because of the complex behaviour of fluid flow over time. The automated optimization approach uses mathematical tools to improve our ability to place wells at the optimal locations and determine the optimal controls for well operation.

In the literature, gradient-based and gradient-free optimization techniques have been reported for well placement/rate optimization. In gradient-based optimization methods, the derivative, or gradient, of the objective function with respect to the decision variables is determined to obtain the minimum or maximum value of the objective function. In gradient-free (also known as stochastic) optimization—a