Monitoring Waterflood Operations: Hall Method Revisited

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RESEARCH OBJECTIVES

The principal objective of this research is development of a robust and simple procedure for on-line monitoring of injecting well performance. An important requirement for the method is that it should not require interruption of regular field operations, and should be based on processing data routinely collected in waterflood operations. For example, such data may take the form of injection pressures and injection rates regularly recorded at each individual well as a time series. The results presented here are a part of the field-scale waterflood control system developed jointly by ChevronTexaco, with participation by the University of California, Berkeley, and Berkeley Lab.

APPROACH

Hall's method is a tool for evaluating injecting well performance. It is based on the assumption of radial steady-state flow. However, rigorous implementation of Hall's method requires information about the ambient reservoir pressure. In addition, it is assumed that the radius of influence is constant throughout the observation period. Neither of these parameters can be measured directly.

With this in mind, a series of forward simulations have been combined with analysis of injection pressures/injection rates data acquired from several hundred injection wells used in a waterflood project at the Lost Hills, California, diatomite oil field. The observations have been analyzed and interpreted using the model of steady-state flow. It turns out that inevitable fluctuations of injection pressures and rates can be used for estimation of an effective reservoir pressure, which in turn can be used for rigorous implementation of the Hall's method.

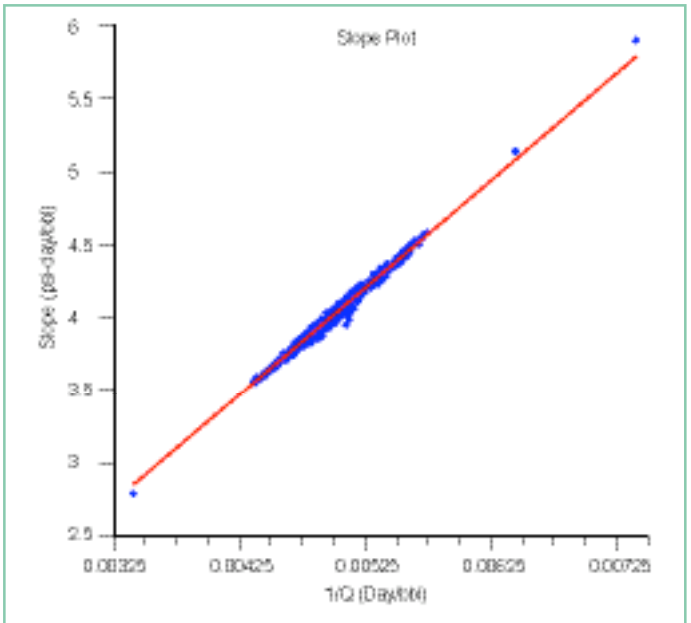

Figure 1. The slope analysis yields the reservoir pressure estimate by fitting injection pressures/injection rates data in special coordinates.

ACCOMPLISHMENTS

A new method called slope analysis has been proposed, based on analysis of Hall plot slope variations. This method produces an estimate of an apparent average reservoir pressure. As input, this method requires only time series of injection pressures and rates, which are routinely collected in the course of a waterflood. An automatic system of data acquisition has been implemented in the field, with measurements sent daily to a computer via the internet. As regular waterflood operations go on, the computer automatically processes the data, using a suite of custom-developed software tools.

The slope method has been verified both on synthetic and field data (Figure 1). It has been demonstrated that using the reservoir pressure estimates obtained by this method leads to correct interpretation of the Hall plot. At the same time, examples show that if such corrections are not done, the interpretation may be incorrect.

SIGNIFICANCE OF FINDINGS

The developed method is based on simple calculations and can be routinely applied for on-line injection-well performance monitoring. It can also be used in the petroleum industry, as well as in underground waste injection projects, where conventional well-performance evaluation procedures require interruption of operations and impose significant costs. The procedure has been incorporated into an injection control loop. Reservoir pressure maps, drawn based on slope analysis at multiple wells, make possible early detection of water breakthrough and reservoir compartmentalization.

RELATED PUBLICATION

Silin, D. B., R. Holtzman, T. W. Patzek, and J. L. Brink, Monitoring waterflood operations: Hall's Method revisited. SPE Paper 93879, Presentation at the 2005 SPE Western Regional Meeting held in Irvine, CA, U.S.A., March 30–April 1, 2005. Berkeley Lab Report LBNL-56928

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