A Comprehensive, Statistically Based Method to Interpret Real-Time Flowing Measurements

DE-FC26-03NT15402

Goal

The goal of the project is to develop a procedure that will allow the determination of the inflow profile (the rates of oil, gas, and water as a function of distance) in horizontal and deviated multilateral wells.

Performers

University of Texas at Austin, Austin, TX

Texas A&M University, College Station, TX

Results

Achieving the project objectives requires the development of models of energy and fluid flow. Researchers have developed a near-wellbore model of the rate of fluid temperature change as flow moves toward a wellbore. Another model applies the results from the first to yield a temperature profile along the wellbore. Both models have been completed and proof-tested.

Benefits

Over the last 20 years horizontal well technology (including near-horizontal and multilateral wells) has become one of the oil and gas industry's main routes of production. With this experience comes knowledge of pitfalls: Horizontal wells rarely produce over their entire interval, and often they experience entry of various fluids at different locations. None of these effects are desirable, and all reduce the profitability of the well.

The goal of intelligent-well technology is to remediate these problems by shutting off flow in sections of a horizontal well by relying on data indicating downhole values. The technology also rests on being able to locally identify the problem sections, which is the ultimate benefit of this work. Project researchers are developing methods to generate information from downhole sensors that would enable the operator to remediate the well successfully.

Coupled with intelligent-well methods, the technology should prolong the life of horizontal wells, increase reserves, and decrease unwanted water production in wells that contain permanent downhole sensors.

Background

This work results from the confluence of two technologies, one fairly old and the other new. The old technology is the use of temperature measurements to infer inflow profiles—which fluids are entering a wellbore and where—in vertical wells. Although not without interpretation issues, vertical profiles are fairly easy to infer because the wells are aligned with the geothermal gradient. Horizontal wells, on the other hand, are aligned perpendicular to the geothermal gradient, which means that any temperature changes inferred are the result of subtle effects, such as Joule-Thompson cooling and viscous heating. The newer technology is the use of permanent downhole temperature sensors. Largely located in horizontal wells, this information is temporally and spatially voluminous, which suggests that a statistical approach would be useful in interpretation.

The ability to interpret such large datasets lags the collection of the data. The goal of the work is to develop, test, and apply a model that will provide inflow interpretation based on temperature.

Summary

The near-wellbore, or inflow, model of the temperature changes was completed early in 2005. The second model, the wellbore model, also was completed. It was first thought that these two models could be run sequentially, but inconsistent results (discontinuities in the temperature profile) indicated the models must be run together.

Researchers have concluded that the temperature changes are tiny, but under the correct circumstances can be used to characterize inflow profiles.

Current status (February 2007)
The focus of the recent work is on understanding and writing a computer simulation that models deviated multilateral wellbores. Excellent progress has been made. The simulator is being constructed. All the proposed work has been successfully completed.

Funding
This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS26-02NT15375, PRIME (Public Resources Invested in Management and Extraction), May 31, 2002.

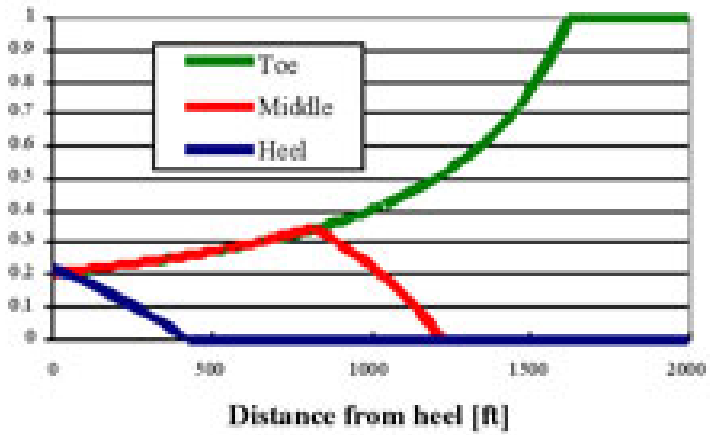
Publications
Yoshioka, K., Zhu, D., Hill, A.D., and Lake, L.W., "Interpretation of Temperature and Pressure Profiles Measured in Multilateral Wells Equipped with Intelligent Completions," SPE 94097, presented at the 14th Europec Biennial Conference, Madrid, Spain, June 13-16, 2005.

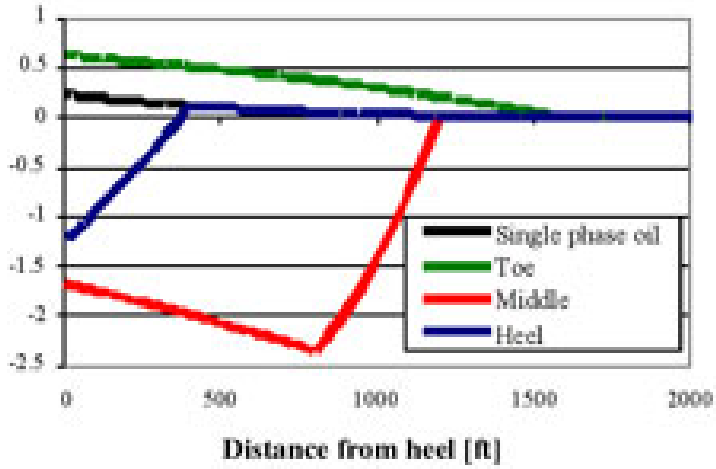
Yoshioka, K. Zhu, D. Hill, A.D., Dawkrajai, P., and Lake, L.W., "Comprehensive Model of Temperature Behavior in a Horizontal Well," SPE 65656, presented at the SPE Annual Technical Conference and Exhibition, Dallas, TX, 2005.

Project Start: August 1, 2003
Project End: January 15, 2007

Anticipated DOE Contribution: $929,995
Performer Contribution: $239,471 (20 percent of total)

Contact Information
NETL – Chandra Nautiyal (chandra.nautiyal@netl.doe.gov or 918-699-2021)
U. of Texas – Larry Lake (larry_lake@mail.utexas.edu or 512-471-8233)





Sample calculations of water holdup (top) and temperature profile (bottom) for a high-rate horizontal well. Water holdup is the fraction of the flowing wellbore fluid that is water. The temperature profile indicates that small—but detectable—changes occur during flow and that the entry of water is observable. “Toe,” “Middle,” and “Heel” mean that water enters the horizontal intervals from 1,600-2,000, 1,000-2,000, and 400-2,000 feet, respectively.