SPE 110097

Analyzing Simultaneous Rate and Pressure Data From Permanent Downhole Gauges

Himansu Rai, SPE, and Roland N. Horne, SPE, Stanford University

This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

Abstract

Permanent downhole gauge data provide us with reservoir information in space and time and aid in well and reservoir management. Interpretation of permanent downhole gauge data is a fairly new problem and several outstanding issues remain in this area.

This paper addresses some of the challenges in analyzing flow rate data and pressure data from permanent downhole gauges - development of improved algorithms for reliable and accurate identification of transient break points (to separate transients into relevant subsections), and investigating the impact of continuous downhole rate data in analyzing well tests.

We tested four different algorithms, one based on the stationary Harr wavelet transform method and others based on nonwavelet approaches such as Savitzky-Golay Smoothing Filters and a novel pattern recognition approach called the Segmentation Method. These four methods were developed for accurate and reliable identification of break points using both pressure and rate data.

The new methods developed in this paper were applied to real field data and the results were compared to the spline wavelet-based approach. All the nonwavelet approaches showed significant improvement over the wavelet-based method in identifying the true break points and avoiding false break points, thus reducing manual editing of break points. Also, significant difference in the estimates of permeability and skin was observed by using continuous rate information instead of average rate data for interpreting transient pressure data.

These new algorithms find their application in the interpretation of permanent downhole gauge data using conventional well test interpretation methods, to obtain dynamic information about changes in properties of the well and reservoir. The use of continuous downhole rate data can have significant advantage in well test interpretation.

Introduction

Over time, permanent downhole gauges (PDG) have gained popularity in the oil and gas industry, due to their effectiveness in providing real time information about the well condition. This is reflected in the increased number of wells in which permanent downhole gauges are being installed. Data from permanent downhole gauges have the capacity to provide us with information whose use is limited only by our interpretation capabilities. PDG data can be used for determining reservoir parameters, appropriate recovery schemes for enhanced oil recovery and better reservoir management. The data can also be used for day-to-day monitoring of well conditions like the development of skin, completion performance and evaluating the performance of stimulation or workover jobs.

Earlier, in the absence of continuous rate data, an average estimation of rate was made from the available pressure data but now with new tools the continuous sampling of rate together with pressure can help in eliminating this step and hence possible ambiguity in the flow rate estimation. The combined availability of downhole rates and pressure has the potential to provide a very powerful framework for extracting more information about the well and the reservoir. This information is certainly more valuable and can contain information about the reservoir at a considerable larger radius of investigation than that obtained by a single transient test performed on the well over a limited period of time.

Permanent downhole gauge data are recorded under dynamic changes occurring in the well and the reservoir. Athichanagorn et al. (2002) developed a spline wavelet-based methodology for the preprocessing of pressure data before using it for interpretation purpose. Khong (2001) introduced some important improvements in the wavelet processing methodology.

Accurate and reliable identification of transient break points is very important for further analysis of the data (Horne, 1995). Limitations of the current time-invariant spline wavelet-based approach of break point identification were studied and four alternate algorithms were proposed for improving the accuracy and reliability of break point estimation. The proposed methods were applied to real field data and the results compared to the time-invariant spline wavelet based approach. The proposed Haar wavelet based approach did not show any tangible improvement but the other three approaches showed considerable improvement over the spline wavelet-based approach.