ROBUST WELL TEST INTERPRETATION USING NONLINEAR REGRESSION WITH PARAMETER AND DATA TRANSFORMATIONS

Aysegul Dastan[1], Albertt Tarantola[2], and Roland Horne[1]
[1]Stanford University, Long Beach, CA 90802, ershaghi@usc.edu
[2]Institut de Physique du Globe de Paris, Long Beach, 90802

Nonlinear regression used in well test interpretation is a relatively well-established technique. However, sensitivity to noise, unacceptably wide confidence intervals, and dependency on starting guess make this widely-used technique vulnerable to issues commonly observed in real data sets. In this work, we show significant improvements in nonlinear regression by using transformations on the parameter space and the data space. In addition to providing more accurate results (narrower confidence intervals), faster convergence, and reduced sensitivity to starting guesses, our technique also provides noise reduction and data compression. The approach is directly applicable to other techniques developed for reservoir modeling and analysis, including multifractured horizontal wells, deconvolution, derivative analysis, and permanent downhole gauges. The logarithm of permeability has been used in some applications for parameter estimation and it is known to improve the performance. In this work, we derive Cartesian transformation formulas for common well test parameters and show that the transformed parameters provide significant performance improvement. Cartesian transformed parameters provide faster convergence, more accuracy, and wider tolerance to starting guesses. In the second part of this paper we discuss wavelet transformations of the data set. The wavelet transform makes it possible to realize certain interpretation operations simultaneously, including compressing and denoising the data. We show that the wavelet transform handles complicated and long data sets with many data points (e.g. coming from permanent downhole gauges) without loss of information. For the wavelet transform, it is possible to use only a few wavelet coefficients and achieve the same converged result as when using all the data. Our significant new contributions are: 1. Novel nonlinear regression algorithms that are faster, and more robust to poor initial guesses. 2. Analysis of massive data sets from permanent downhole gauges without loss of information. 3. Inherent noise removal during pressure transient analysis.