Holistic Fracture Diagnostics: Consistent Analysis of Pre-Frac Injection/Falloff Data

Abstract

Since the introduction of the G-function derivative analysis, pre-frac diagnostic injection tests have become a valuable and commonly used technique. Unfortunately, the technique is frequently misapplied or misinterpreted leading to confusion and misdiagnosis of fracturing parameters. A consistent method of analysis of the G-function, its derivatives, and its relationship to other diagnostic techniques including square-root(time) and log(Δp_{wf})-log(Δt) plots and their appropriate diagnostic derivatives must be applied to obtain useful results.

Pre-frac diagnostic injection test analysis provides critical input data for fracture design models, and reservoir characterization data used to predict post-fracture production. An accurate post-stimulation production forecast is necessary for economic optimization of the fracture treatment design. Reliable results require an accurate and consistent interpretation of the test data. In many cases closure is mistakenly identified through misapplication of one or more analysis techniques. In general, a single unique closure event will satisfy all diagnostic plots or methods. All available analysis methods should be used in concert to arrive at a consistent interpretation of fracture closure.

Relationship of the pre-closure analysis to after-closure analysis results must also be consistent. To correctly perform the after-closure analysis the transient flow regime must be correctly identified. Flow regime identification has been a consistent problem in many analyses. There remains no consensus regarding methods to identify reservoir transient flow regimes after fracture closure. The method presented here is not universally accepted but appears to fit the generally assumed model for leakoff used in most fracture simulators.

Examples are presented to show the application of multiple diagnostic analysis methods. The goal of this paper is to provide a method for consistent identification of after-closure flow regimes, an unambiguous fracture closure time and stress, and a reasonable engineering estimate of reservoir flow capacity from the pressure falloff data, without requiring assumptions such as a known reservoir pressure.

BIOGRAPHY

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Robert D. Barree is president and principal investigator of Barree & Associates, a consulting firm specializing in stimulation and well performance optimization. Previously Dr. Barree was a Senior Technical Consultant at Marathon's Petroleum Technology Center. His 24 years' experience at Marathon developed extensive expertise in the areas of well completion, stimulation, numerical simulation, special core analysis, formation damage, rock mechanics, and equipment design. He has been involved in the development of hydraulic fracture design simulators and fracture diagnostic procedures since 1980 and is the primary author of the fully three-dimensional hydraulic fracture simulator GOHFER.

Dr. Barree is the author of more than fifty technical publications. He has served as SPE Distinguished Lecturer on the topic of new philosophies in hydraulic fracturing. Dr. Barree has also served on many technical committees for SPE annual and regional meetings, Applied Technology Workshops, and Forum Series. He is a registered Professional Engineer in the State of Colorado and holds degrees in Petroleum Engineering from the Pennsylvania State University and Colorado School of Mines.