



SPE 139097

Applying Innovative Production Modeling Techniques to Quantify Fracture Characteristics, Reservoir Properties, and Well Performance in Shale Gas Reservoirs

Mark A. Miller, Lucid Reservoir Technologies; Creties Jenkins, DeGolyer & MacNaughton; and Rakesh Rai, Object Reservoir

Copyright 2010, Society of Petroleum Engineers

This paper was prepared for presentation at the SPE Eastern Regional Meeting held in Morgantown, West Virginia, USA, 12–14 October 2010.

This paper was selected for presentation by an SPE program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of SPE copyright.

Abstract

In order to more accurately characterize reservoir and hydraulic fracture properties from well performance, a workflow has been developed that effectively integrates variable quality data from a variety of sources. This workflow applies analytical techniques designed specifically for shale gas wells followed by as-needed numerical modeling. The analytical techniques can be applied to multiple wells through time to: a) identify groupings of like-performing wells, b) detect wells with anomalous behaviors, c) develop hypotheses about production mechanisms, and d) choose specific wells for more detailed analysis and numerical modeling. Numerical modeling provides the functionality needed for complex mechanism forensics, performance forecasting, and completion optimization studies.

Conventional numerical models typically use finite-difference grids, but these are neither sufficiently complex nor sufficiently flexible for shale gas reservoirs. For this reason, a finite-element modeling technology has been applied that places a large number of closely-spaced nodes near hydraulic fractures, “where all the action takes place” in the early life of a well. The finite-element technique also allows complex fracture geometries to be modeled.

This workflow, incorporating analytical and numerical solutions, has been applied to multiple shale gas projects, including industry consortia in the Haynesville (US) and Montney (Canada) shales and individual operator projects in the Woodford (US), Horn River (Canada), and Marcellus (US) shales. Through the application of these techniques, fracture and reservoir properties have been characterized and uncertainty associated with forecasted well performance has been reduced. This work has profound implications for quantifying gas reserves, understanding those factors responsible for variations in well performance, and for optimizing well spacing, lateral lengths, and completion techniques.

Introduction

Gas rates from shale gas wells are comparable to those of conventional wells as a result of rapidly-evolving horizontal drilling and well stimulation technologies. However, an understanding of the factors controlling production rates and recoveries lags behind the knowledge derived from decades of gas production from conventional reservoirs. Some of the specific difficulties in characterizing shale gas production include:

- An inability to distinguish between hydraulic fracture and reservoir contributions from limited production/pressure data. This makes it difficult to understand whether better performing wells are characterized by greater effective fracture size and conductivity, higher reservoir permeability, or some combination of both.
- Incomplete knowledge about the geometries of staged hydraulic fractures in horizontal wellbores. In some cases it is not clear whether these fractures have a relatively simple bi-wing structure, or are much more complex due to the interplay of geomechanical properties, natural fractures, and local stresses.
- Uncertainty regarding the contribution of the stimulated reservoir volume (SRV) compared to the surrounding unstimulated reservoir volume. If the permeability of the unstimulated volume is so low that little gas will be contributed over the life of a well, it may be necessary to space wells such that their SRVs abut.
- A lack of understanding as to how variations in petrophysical properties (including porosity, permeability, free gas saturation, and adsorbed gas volumes), uncertainty about the accuracy of these petrophysical measurements, and the contributions of different reservoir layers impact well performance.