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Beyond Decline Curves: Life-Cycle Reserves Appraisal Using an Integrated Work-Flow Process for Tight Gas Sands

J.A. Rushing, SPE, Anadarko Petroleum Corporation; K.E. Newsham, SPE, Apache Corporation; A.D. Perego, SPE, Anadarko Petroleum Corporation; J.T. Comisky, SPE, Apache Corporation; and T.A. Blasingame, SPE, Texas A&M University

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Abstract

Decline curve analysis is often either the only or the primary tool used for reserve evaluations in tight gas sands. However, the flow and storage properties characteristic of low-permeability sands often preclude *accurate* assessments using *only* or *primarily* decline curve analysis, especially early in the productive life. The most accurate reserve estimates incorporate multiple data sources and the appropriate evaluation techniques. Therefore, this paper presents a reserves appraisal work-flow process that complements traditional decline curve analyses with comprehensive and systematic data acquisition and evaluation programs that integrate both static and dynamic data.

Our approach—which has been developed specifically to incorporate the production characteristics of tight gas sands—is an adaptive process that allows continuous but reasonable reserve adjustments over the entire field development and production life cycle. Implementing this process will prevent unrealistic (either too low or high) reserve bookings. Although it is applicable during any field development phase, our work-flow process is most beneficial during early stages before true boundary-dominated flow conditions have been reached and when reserve evaluation errors are most likely.

Introduction

Estimating reserves in any type of hydrocarbon resource is an important process for all publicly traded oil and gas companies. The reserve estimating process is necessary for assessing the value of both individual producing properties as well as the entire company. Accurate reserve assessments are also extremely critical since the reserves value may have a direct impact on company earnings and the overall balance sheet. Moreover, the value of booked reserves may influence the cost and availability of capital required for a company's future growth. Perhaps most importantly, reserves assessment is a legal requirement to satisfy reporting and disclosure requirements set forth by various regulatory and governmental agencies.

The most widespread reserve estimating techniques historically used by the oil and gas industry were initially developed for conventional oil and gas reservoirs[1-7] but have been routinely extended (sometimes inappropriately) to unconventional reservoirs. The most common reserve estimating methods include:

- curve fitting existing production data using the traditional Arps[8] decline curve techniques and extrapolating the model to estimate remaining reserves and production at some future economic conditions;
- calculating original volumetric gas-in-place and applying a recovery factor to estimate reserves. Recovery factors are estimated from field analogues or computed using a model (*i.e.*, reservoir simulation, material balance, *etc.*);
- using conventional material balance models to estimate original gas-in-place and applying a recovery factor to estimate reserves and future production; and
- history matching well and/or field production with a reservoir simulator, and estimating future production and reserves with the calibrated model.

Although the oil and gas industry has long recognized that the most accurate reserve assessments are made by integrating multiple analysis techniques, the most widely used method—especially for fields with sufficient production histories—has typically still been just decline curve analysis. Depending on the type, quantity and quality of available data, decline curve analysis is sometimes the only method available for evaluating reserves.

We should note that, when applied under the correct conditions, decline curves are excellent tools for estimating reserves in conventional oil and gas resources. Unfortunately, many of us in the industry either have forgotten or have chosen to ignore the conditions under which use of the Arps[8] decline curves are appropriate. Application of a decline curve methodology using the Arps models *implicitly* assumes the following:[9]

- extrapolation of the curve fit through the *current* or historical production data is an accurate model for *future* production trends;