Theories of Arps' Decline Curve Exponent and Loss Ratio, for Saturated Reservoirs

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DOI

http://dx.doi.org/10.2118/172128-MS

Document ID

SPE-172128-MS

Publisher

Society of Petroleum Engineers

Source

Abu Dhabi International Petroleum Exhibition and Conference, 10-13 November, Abu Dhabi, UAE

Publication Date

2014

Abstract

Rate decline curve analysis is an essential tool in predicting reservoir performance and in estimating reservoir properties. In its most basic form, decline curve analysis is to a large extent based on Arps' empirical models that have little theoretical basis. The use of historical production data to predict future performance is the focus of the empirical approach of decline analysis while the theoretical approach focuses on the derivation of relationships between the empirical model parameters and reservoir rock/fluid properties; thereby establishing a theoretical basis for the empirical models. Such relationships are useful in formulating techniques for reservoir properties estimation using production data.

Many previous attempts at establishing relationships between the empirical parameters and the rock/fluid properties have been concerned primarily with the exponential decline of single phase oil reservoirs. A previous attempt to establish the theories of hyperbolic decline of saturated

reservoirs (multiphase) have yielded an expression relating the Arps' decline exponent, to rock/fluid properties. However, the values of exponent computed from the expression are not constant through time, whereas, the empirically-determined exponent b is a constant value.

This work utilizes basic concepts of compressibility and mobility to justify the dynamic behaviour of the values obtained from the existing theoretical expression of the previous theory; to prove that the expression, though rigorously derived, is not the theoretical equivalence of the empirical Arps' b-exponent; and finally, to properly to offer a new logical perspective to the previous theory relating b-exponent to rock and fluid property. Ultimately, this work presents, for the first time, a new consistent theoretical expression for the Arps' exponent, b. The derivation of the new expression is still founded on the concept of Loss Ratio, as in previous attempts; however, this latest attempt utilizes the cumulative derivative of the Loss Ratio, instead of the instantaneous derivative implied in the previous attempt.

The new expression derived in this work have been applied to a number of saturated reservoir models and found to yield values of b-exponent that are constant through time and are equivalent to the empirically-determined b-exponent.