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The Determination of Minimum Tested Volume from the Deconvolution of Well Test Pressure Transients

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Abstract

Radius of investigation and tested volume are important results of well test analysis which can make or break future field development. Currently, their evaluation is either approximate or relies on a complete analysis of the transient pressure response using an appropriate model. A new method is proposed that uses the deconvolved derivative response to determine a minimum tested volume. It is accurate and does not rely on further transient analysis.

The method can be applied to any oil or gas well test. It is simple and only requires input of data that is known at the time of testing. Furthermore, if the uncertainty in the deconvolution is quantified, then the uncertainty in tested volume is also defined.

Field examples of both oil and gas well tests are presented which demonstrate how tested volume is easily calculated. Radius of investigation is calculated from the tested volume by making assumptions about the reservoir geometry. The method relies on a good deconvolution algorithm which can also compute the error bars in the derivative response.

Recent advances in deconvolution algorithms have enabled the use of this simple but powerful new method to accurately calculate tested volume without the need for complex transient analysis.

Introduction

In the last thirty years, there have been many advances in well test analysis (Earlougher[1], 1977, Gringarten[2], 2007) of which deconvolution is probably the most recent. In the context of the analysis of pressure transients recorded during the testing or production of a well, deconvolution is the extraction of an equivalent single rate pressure response from the actual well response which is usually a continuous variation in rate and pressure. Within its known limitations (Levitan[3], 2004), it is a powerful technique because it allows the engineer to see the transient response of the well and reservoir without the complexity of the effects of superposition. Furthermore, the deconvolved response applies to the entire duration of the test rather than the duration of any particular constant rate period within the test (usually a build-up).

A well test analysis work flow starts with the diagnosis of the transient response using a log-log plot of the pressure change and derivative response. Flow regimes are identified and an appropriate model selected. Often the models are analytical and they describe the pressure response of the well producing at constant rate for a given set of model parameters. The principle of superposition is then used to convert the constant rate response into the response due to the actual rates at which the well flowed. The resulting pressure history simulation is then compared with the observed data on a variety of plots. The parameters of the model are adjusted manually or automatically using regression techniques (Levenberg-Marquardt[4,5]) until the best fit between the model simulation and the observed pressure response is obtained. If a numerical model is selected, a similar process is used but without the constraints of linearity that are imposed by the use of analytical models and superposition (Houze[6,7] et al, 2002, 2007).

Much effort has been put into developing complex models (Bourdet[8] 2002), to match the variety of derivative responses that are observed during both well tests and also - with the increased use of permanently installed down hole pressure gauges - during well production. There exists a multitude of models and associated parameters that will match a given observed response and this inherent non-uniqueness in the analysis process means that a model needs to be selected carefully - “all models are wrong but some are useful” (Box[9], 1987). Deconvolution helps the analysis by identifying the character of the transient response without the additional complication caused by the superposition of multiple flow rates. However, depending on the quality of data, it may not be possible to extract a unique deconvolution. This compounds the problem of non-