Datapages/Search and Discovery Article #90209©2014 PAPG/SPE Annual Technical Conference, 25-26 November 2014, Islamabad, Pakistan.

Characterizing and Developing Tight Gas Reservoirs

Shahnawaz Soomro[1] and Temoor Muther[1]

[1]Mehran University of Engineering and Technology, Jamshoro

Extended Abstract

Tight gas is becoming an increasingly important asset for petroleum related sectors. Appropriate and proper reservoir characterization plays a vital role to the success of a tight gas play.

This paper presents a straight forward and technically sound approach for characterizing and planning development of tight gas reservoirs (TGRs).
Characterizing a reservoir is simply a determination of basic reservoir characteristics and it involves proper identification of dominant flow regime from acquired well test data. In TGRs the reservoir flow regime can be revealed using diagnostic plots of pressure transient and its derivative but using this technique may lead to erroneous outcomes due to extensive wellbore storage effect, heterogeneity and complexity of reservoir. To overcome such issues transient analysis techniques that utilize higher order pressure derivatives integrated with rate transient analysis (RTA) can reduce uncertainties associated with well test analysis and provide better estimate of reservoir dynamic parameters. Characterizing the reservoir results in determination of reservoir and production characteristics (permeability, fracture length, flow regime).

For planning the development of TGRs, Performance evaluating models are required that can predict well performance and the rate of increase of accessible recovery over time. Application of appropriate economic model and well constraints to the proposed model allows identifying a practical range of EUR values that are more reliable than that provided by conventional decline curves. This process can be applied to reserve evaluation as well as optimizing well spacing in the reservoir.

To characterize the well and reservoir parameters in a fractured well, well test data analysis can be used. However in TGRs the low permeability slows down the reservoir response to the pressure disturbance during transient testing, which causes the wellbore storage effect to be significantly long. As a result, the early time reservoir response may be distorted or even be masked by the extended wellbore storage effect (Bahrami and Siavoshi, 2005).

TGRs typically require relatively long pressure buildup to reach the radial flow regime, which is often not practical. In the case of a hydraulically fractured well, the wellbore volume is larger making the wellbore storage effect to be longer. The near wellbore region is a more complex due to presence of hydraulic fractures and heterogeneity of the reservoir. Therefore for hydraulically fractured reservoirs, the conventional pressure build-up testing and analysis may fail to provide reliable results. Consequently, the reservoir flow regimes may not be clearly revealed on diagnostic plots of transient pressure and its derivative, which results in erroneous well test analysis outcomes (Restrepo, 2009).

A pressure transient breaks into several flow regimes, each seeing deeper in reservoir than the last. Depending on well completion type, completion configuration, reservoir geological and geometric attributes, different flow regimes might be revealed on pressure transient data (Bourdarot, 1998). Based on derivations of fluid-flow and diffusivity equations, on the pressure transient derivative curve, the slope of +1 shows wellbore storage effect, the slopes of -0.5 (-1/2), +0.5 (+1/2), +0.25 (+1/4) and +0.36 (approx.. +1/3) indicate spherical, linear, bi-linear and elliptical flow regimes respectively, and zero slope indicates radial flow regime (Badazhkov, 2008; Bourdarot 1998). When radial flow regime is established in the reservoir, reliable values of permeability and skin factor can be calculated for the formation layers that contributed to the test. Therefore, diagnosing the radial-flow regime is critical to quantitative well test interpretation (Badazhkov, 2008).

Following flow regimes will be discussed.
Reservoir flow regimes in non-fractured horizontal wells.

Flow inside hydraulic fractures.
Flow regimes in case of a well with single hydraulic fracture.

Reservoir flow regimes in a multistage hydraulically fractured horizontal well.

Also well test analysis using pressure derivatives will be discussed and the advantage of 2^{nd} derivative over first derivative diagnostic plot will be presented.

For planning development of tight gas reservoirs, models will be used for reserves evaluation that incorporates some modern recovery plots for EUR estimation. Further a spacing optimization plot will be generated to determine the optimum spacing for the reservoir, the plot will use EUR per well and recovery factor as a function of well spacing.

Radial flow regime can be indicated by zero slope line with a certain intercept on the first derivative curve, and zero slope line with zero intercept on the second derivative curve.

End of wellbore storage effect can be detected using the second derivative technique. The first extreme point on the second derivative plot can approximate the time at which wellbore storage effect is ended.
In low permeability TGRs, the flow regimes might not clearly be revealed on the diagnostic pressure build-up plots. The semi-Log plot of first and second derivative of pressure transient versus time formation can be used to reduce the uncertainties associated with analysis of tight formation well-test data.

Radial flow regime can be predicted using curve fitting on the second derivative points from the second extreme point on second derivative, to the zero value point at around 1.5 cycles after wellbore storage effect.

The extrapolated second derivative curve can be used to determine the first derivative curve, and therefore permeability and skin can be estimated.

As a rule of thumb, radial flow regime is assumed to be started from 1.5 time log cycles after pure wellbore storage effect. However depending on well and reservoir parameters, it can vary from 1.0 to 2.5 log cycles. Therefore for radial flow regime prediction based on second derivative curve, sensitivity analysis needs to be performed for effect of skin and permeability on wellbore storage duration.

For development of TGRs, EUR evaluation models are there which can be used to obtain a robust range of EUR values, also a spacing optimization plot is presented to assist professionals in optimizing the development of tight gas fields.