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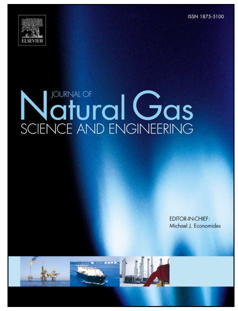

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Impact of Non-linear Transport Properties on Low Permeability Measurements

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Abstract

The results of modeling nonlinear transport properties on a plug scale for steady state, unsteady state, pulse decay and sinusoidal pressure measurements are presented. We include the gas slippage (Klinkenberg corrections) and pressure dependent density effects.

To validate the modeling, we compare it to analytical calculations based on an assumption of constant mass flow once the transients have dissipated for steady state models. Validation of the other measurement protocols is performed by comparison to finite difference calculations.

For low permeability samples, significant pressure drops must be modeled to obtain large enough flow rates to allow accurate measurement in the laboratory. We limited ourselves to 100 psi pressure differences because of the large influence of effective stress on gas density that would be present for larger pressure differences. Flowing pressures of this magnitude imply significant pressure dependent density effects, which reduce the flow rates. In contrast, gas slippage increases the transport of gas. The result is that nearly identical fits are obtained for widely varying magnitudes of permeability and gas slippage. This result is obtained for all of the modeled measurement protocols. We introduce a new technique to interpret the modeled data, the "k_0-b plot". The method allows the values of k_0 and b to be extracted if multiple measurements are performed at different mean pressures. The technique is also compared to laboratory data

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