UNDERSTANDING FLOWBACK AS A TRANSIENT 2-PHASE DISPLACEMENT PROCESS: AN EXTENSION OF THE LINEAR DUAL-POROSITY MODEL

Daniel Obinna Ezulike (University of Alberta), Robert Vincent Hawkes (Trican Well Service Ltd.), Hassan Dehghanpour (University of Alberta)

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ABSTRACT
Existing rate transient models for fractured horizontal wells assume single-phase fluid flow. This assumption is violated in early times, when hydraulic fractures (HF) are filled with fracturing water and hydrocarbon. This calls for a model that captures the transient 2-phase (gas/oil + water) flow in HF, and can be used for history matching rate and pressure data measured during flowback operations. Existing models for analysing multiphase data from solution-gas drive and high-water-saturation conventional reservoirs cannot be applied to flowback data because of simplifying assumptions such as (1) constant average phase saturation with time, (2) constant rate or pressure well constraint and (3) radial flow. This paper extends the existing linear dual-porosity model (DPM) and develops a flowback analysis model (FAM) which accounts for transient multiphase flow in HF. The proposed model adopts an explicit dynamic-relative-permeability (DRP) function of time for hydrocarbon phase in the fracture network to account for water-saturation drop. This model assumes that water-saturation drop with time causes a corresponding non-linear increase in hydrocarbon relative-permeability in HF. The DRP function is obtained from analysing cumulative hydrocarbon + water measured during flowback operation and drainage relative-permeability curves from existing literature. Fifteen tight oil, tight gas and shale gas wells completed in the Bluesky, Cardium, Evie, Muskwa and Otter-Park Formations were used for this study. The resulting DRP parameters control the rate of water-saturation drop in HF (clean-up rate). DRP is incorporated into the existing DPM to obtain FAM flow equations. This paper attempt solving these equations with Mellin transforms under variable bottomhole rate and pressure well constraints. FAM converges to the existing DPM at the limit of residual water-saturation. DRP captures the fluid physics from flowback phase till the “full” hydrocarbon production phase in the life of a multifractured horizontal well. The application of FAM on transient 2-phase flowback data (rate + pressure) could help estimate key reservoir parameters (e.g. effective HF half-length) and evaluate flowback performance (e.g. percentage of total inject fluid left in HF and matrix and the speed of HF clean-up). Results from this study is applicable for interpreting 2-phase flowback data from multi-fractured horizontal wells completed in tight and shale reservoirs. This study allows the industry to forecast hydrocarbon recovery from flowback data and estimate/predict the effectiveness of flowback operations.

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