Multiwell Retrospective Testing = MRT

Specific type of Production Analysis (PA) workflow based on correlation between multi-well production/injection history and bottomhole pressure history from permanent downhole gauges (PDG).

The key simulation engine of MRT is Pressure Convolution which is based on Unit-rate Transient Responses (UTR) retr ieved from Production rates / PDG data history by means of Pressure Deconvolution.

It does not require new data acquisition at well site and makes use of historical dynamic data records, usually few months or longer.

Motivation

Production rate in producing well depends on its productivity index J, current formation pressure p_e and current BHP p_{wf}:

(1) $$q_1^{\uparrow}(t) = J \cdot \left(p_e(t) - p_{wf}(t)\right)$$

and as such depends on completion/lift settings (defining $p_{wf}(t)$) and how formation pressure is maintained $p_e = p_e(t)$ over time.

It keeps declining due to the offtakes:

(2) $$p_e(t) = p_e[q_1^{\uparrow}(t), q_2^{\uparrow}(t), q_3^{\uparrow}(t), \ldots]$$

and maintained by either aquifer or Fluid Injection and in the latter case depends on injection rates:

(3) $$p_e(t) = p_e[q_1^{\downarrow}(t), q_2^{\downarrow}(t), q_3^{\downarrow}(t), \ldots]$$

The combination of (1), (2) and (3) lead to the correlation between production rates, injection rates and bottomhole pressure variation.

The ultimate purpose of MRT is to extract maximum information from correlation between the long-term (few months or longer) flowrate history and BHP history (recorded by PDG).

It is essentially based on the fact that BHP in a given well (whether producing or injecting) responds to flowrate variatio n in the same well and may (or may not) respond to flowrate variation in offset wells.

This information is further related to well flow performance and cross-well connectivity.

Goals & Objectives

- Create short-term prediction model on production response to various multi-well production regimes

- Compare the well dynamics and and cross-well connectivity with expectations and identify the candidates for drilling, workover or additional well surveillance
- Assess dynamic reservoir properties

Outputs

Production History	
	Simulated total subsurface flowrate history, $q_t(t)$
	Simulated BHP history, $p_{wf}(t)$
	Simulated formation pressure history, $p_e(t)$
	Simulated Productivity Index history, $J_t(t)$
	Simulated Cross-well interference history, $p_{k \to m}(t)$
Production Forecast	
	Rate forecast under Pressure Control regime, $p_k(t), \{q_m(t)\} \to q_k(t)$
	BHP forecast under Liquid Control regime, $\{q_m(t)\} \to p_{wf,k}(t)$
	Formation pressure forecast under Liquid Control regime, $\{q_m(t)\} \to p_{e,k}(t)$
Diagnostic Metrics	
	Cross-well interference map
	Unit-rate Transient Response Matrix (UTRM)
	Unit-rate Transient Response Spider (UTRS)
	Material Balance Pressure Plot
	Inflow Performance Relationship (IPR)
	Cumulative Productivity Plot (Hall Plot)
	J-plots
	WOR diagnostics
	GOR diagnostics
Primary Well & Reservoir properties	
	Potential drainage volume
	Current dynamic drainage volume
Secondary Well & Reservoir properties	
	Apparent transmissibility

	Apparent skin-factor
	Fracture half-length
	Dynamic fracture pressure threshold

Inputs

Primary Inputs	
	PVT model
	Production/injection history for all wells in a test
	Bottom-hole pressure (BHP) history for at least one well
Additional Inputs	
	Well locations map
	Well schematic
	Surface Well Tests
	Drilled formation pressure, p_d from DST – Drill Stem Test
	Drilled formation pressure, p_d from WFT – Wireline Formation Test
	Production Logging Reports
	Cased-Hole Pressure Transient Test Reports
	SGS – Static Gradient Survey Reports
	Well Intervention History

Applications

Production forecasts	
	Predict formation pressure without shutting wells down and avoiding production deferment
	Short-term production forecasts for different multi-well production scenarios
Selecting well-intervention candidates	
	Identify well-intervention candidates with possible thief production/injection
	Identify well-intervention candidates with possibly inefficient reservoir flow profile

	Identify well-intervention candidates for Rate Optimization
	Identify well-intervention candidates for producer injector conversion
Dynamic Model Calibration	
	Adjusting historical production allocation
	Adjusting the potential reservoir volume extension at different directions
	Adjusting faults / channels / compartmentalization
	Adjusting fracture model

Workflow

MRT @workflow

Examples

MRT @sample

See Also

Petroleum Industry / Upstream / Production / Subsurface Production / Field Study & Modelling / Production Analysis

[MRT @sample] [MRT @workflow]

[Permanent downhole gauges (PDG)] [Pressure Convolution] [Pressure Deconvolution] [Multiwell Deconvolution (MDCV)]

[Radial Deconvolution (RDCV)][RDCV @model][RDCV @sample]

[Cross-well Deconvolution (XDCV)][XDCV @model][XDCV @sample]

[Material Balance Analysis] [Capacitance Resistance Model (CRM)] [Pressure Transient Analysis (PTA)]