FMB Pressure @model

Modelling facility for field-average formation pressure $p(t)$ at any time moment t as response to production flowrates history:

(1) $$A_e\, h_e \int_{p_i}^{p} \phi_e(p)\, c_t(p)\, dp = \Delta Q(t) = Q_t^{\downarrow}(t) - Q_t^{\uparrow}(t) + Q_{GC}^{\downarrow}(t) + Q_{AQ}^{\downarrow}(t)$$

where

$p_i = p(0)$	initial formation pressure	$\Delta Q(t)$	full-field cumulative reservoir fluid balance
A_e	drainage area	$Q_t^{\uparrow}(t)$	full-field cumulative offtakes by the time moment t
h_e	effective formation thickness averaged over drainage area	$Q_t^{\downarrow}(t)$	full-field cumulative intakes by the time moment t
$\phi_e(p)$	effective porosity as function of formation pressure $p(t)$	$Q_{GC}^{\downarrow}(t)$	cumulative gas influx from Gas Cap Expansion
$c_t(p)$	total compressibility as function of formation pressure $p(t)$	$Q_{AQ}^{\downarrow}(t)$	cumulative water influx from Aquifer Expansion

The MatBal equation (1) is often complemented by constant PI model of Bottom-Hole Pressure ($p_{wf}^{\uparrow}(t)$ for producers and $p_{wf}^{\downarrow}(t)$ for injectors):

(2) $$p_{wf,k}^{\uparrow}(t) = p(t) - J_k^{\uparrow\,-1} \cdot \frac{dQ_k^{\uparrow}}{dt}$$		(3) $$p_{wf,\,j}^{\downarrow}(t) = p(t) - J_j^{\downarrow\,-1} \cdot \frac{dQ_j^{\downarrow}}{dt}$$	
where		where	
$p_{wf,\,k}^{\uparrow}(t)$	BHP in k-th producer	$p_{wf,\,j}^{\downarrow}(t)$	BHP in j-th injector
$Q_k^{\uparrow}(t)$	cumulative offtakes from k-th producer by the time moment t	$Q_j^{\downarrow}(t)$	cumulative intakes to j-th injector by the time moment t
$J_k^{\uparrow}$	productivity index of k-th producer	$J_j^{\downarrow}$	injectivity Index of j-th injector

In practice there is no way to measure the external influx $Q_{GC}^{\downarrow}(t)$ and $Q_{AQ}^{\downarrow}(t)$ so that one need to model them and calibrate model parameters to fit available data on production flowrates history and formation pressure data records.

There is a list of various analytical Aquifer Drive and Gas Cap Drive models which are normally related to pressure dynamics $p(t)$:

Gas Cap Drive @model	Aquifer Drive @model
(4) $Q_{GC}^{\downarrow}(t) = Q_{GC}^{\downarrow}(p(t))$	(5) $Q_{AQ}^{\downarrow}(t) = Q_{AQ}^{\downarrow}(p(t))$

which closes equation (1) for the pressure $p(t)$.

Variations

In some specific cases equation (1) can be explicitly integrated:

Slightly compressibility flow	**Low pressure dry gas**
$\{\phi_e = \text{const},\ c_t = \text{const}\}$	$c_t = c_r + \frac{1}{p} \sim \frac{1}{p}$
(6) $p(t) = p_i + \frac{\Delta Q(t)}{V_e \cdot c_t}$	(7) $p(t) = p_i \exp\left[\frac{\Delta Q(t)}{V_e \cdot c_t}\right]$

where

$V_e = A_e\, h_e\, \phi_e$	drainage volume

See Also

Petroleum Industry / Upstream / Production / Subsurface Production / Field Study & Modelling / Production Analysis / Flowing Material Balance Analysis (FMB)

[Material Balance Pressure Plot][Material Balance Pressure @model]