Pseudo Steady State (PSS) fluid flow

Fluid flow with fluid pressure $p(t, \mathbf{r})$ linearly changing in time:

$$p(t, \mathbf{r}) = \psi(\mathbf{r}) + A \cdot t, \quad A = \mathrm{const}$$

The fluid temperature $T(t, \mathbf{r})$ is supposed to vary slowly enough to provide quasistatic equilibrium.

The fluid velocity $\mathbf{u}(t, \mathbf{r})$ may not be stationary.

In the most general case (both reservoir and pipelines) the fluid motion equation is of fluid pressure and pressure gradient:

(1) $$\mathbf{u}(t, \mathbf{r}) = F(\mathbf{r}, p, \nabla p)$$

with right side dependent on time through the pressure variation.

In case of the flow with velocity dependent on pressure gradient only $\mathbf{u} = \mathbf{u}(\mathbf{r}, \nabla p)$) the PSS flow velocity will be stationary as the right side of (1) is not dependant on time.

In terms of Well Flow Performance the PSS flow means:

(2) $$q_t(t) = \mathrm{const}$$
(3) $$\Delta p(t) = |p_e(t) - p_{wf}(t)| = \Delta p = \mathrm{const}$$

During the PSS regime the formation pressure also declines linearly with time: $p_e(t) \sim t$.

The exact solution of diffusion equation for PSS:

(4) $p_e(t) = p_i - \dfrac{q_t}{V_\phi \, c_t} \, t$	varying formation pressure at the external reservoir boundary
(5) $p_{wf}(t) = p_e(t) - J^{-1} q_t$	varying bottom-hole pressure
(6) $J = \dfrac{q_t}{2\pi\sigma} \left[\ln\left(\dfrac{r_e}{r_w} \right) + S + 0.75 \right]$	constant productivity index

and develops a unit slope on PTA diagnostic plot and Material Balance diagnostic plot:

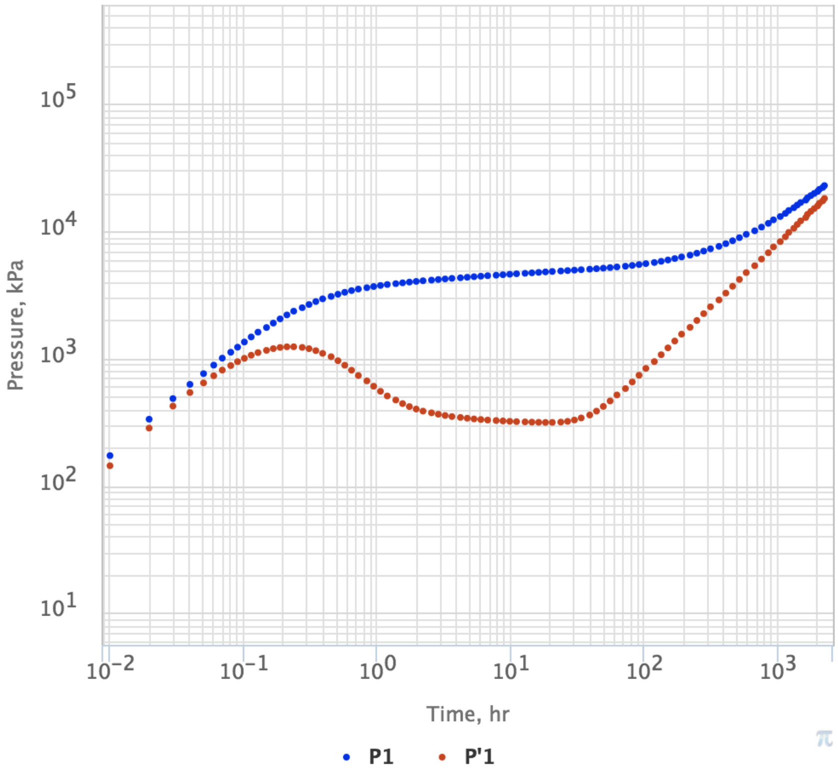

Fig. 1. PTA Diagnostic Plot for vertical well in single-layer homogeneous reservoir with impermeable circle boundary (PSS).

Pressure is in blue and log-derivative is in red.

See Also

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

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