Skin-factor (mechanical)

Normalised dimensionless difference between the sandface bottomhole pressure (BHP) $p_{wf}(t)$ and the sandface reservoir pressure $p(\mathbf{r},t)|_{\mathbf{r} \in \Gamma_s}$ at the boundary Γ_s of damaged reservoir zone A_s:

(1) $$S_M = \frac{2\pi\sigma}{q_t} \cdot \left[p_{wf}(t) - p(\mathbf{r},t)|_{\mathbf{r} \in \Gamma_s} \right]$$

where

q_t	total sandface rate
σ	formation transmissibility at the boundary Γ_s of the damaged reservoir zone A_s
A_s	damaged reservoir zone
Γ_s	boundary of damaged reservoir zone

The (1) can be re-wrriten as:

(2) $$p_{wf}(t) = p^o_{wf}(t)| - \frac{q_t}{2\pi\sigma} \, S_M$$

with the meaning that near-reservoir damage is resulting in additional pressure drop quantified by the value of mechanical skin-factor S_M

It quantitatively characterises permeability change in a thin layer (usually < 1 m) around the well or around the fracture plane, caused by stimulation or deterioration during the reservoir invasion under drilling or well intervention or under routine production or injection.

It contributes to the total skin estimated in transient well testing.

For the radial-symmetric permeability change around the well it can be estimated by means of Hawkins equation:

(3) $$S_M = \left(\frac{k}{k_s} - 1 \right) \, \ln \left(\frac{r_s}{r_w} \right)$$

where

r_w	well radius from drilling
r_s	damaged reservoir ($k_s \neq k$) radius: $r_s > r_w$ (the most typical range is: $r_w < r_s < 1$ m)
k	absolute formation permeability in the undamaged reservoir zone away from well location
k_s	absolute formation permeability in the damaged near-well reservoir zone

The definition of S_M in (3) suggests that:

- deteriorated permeability of the near-well reservoir zone $k_s < k$ is characterised by a positive skin-factor $S > 0$,
- improved permeability of the near-well reservoir zone $k_s > k$ is characterised by a negative skin-factor $S < 0$.

The most popular practical range of skin-factor variation is $-5 < S_M < 8$ with upper limit may sometimes extend further up.

For the negative skin-factor values there is a natural limitation from below caused by the Mechanical Skin concept itself.

The Mechanical Skin concept is trying to approximate the true inhomogeneity of the near and far reservoir zones with homogenous far reservoir model and additional pressure drop at the well wall.

In case of high permeability

The values of $S_M < -5$ are usually not supported by the majority of commercial simulators as these values assume almost infinite permeability in the 10 m area around the well see (4) below:

(4) $$k_s = k \cdot \left[1 + \frac{S_M}{\ln \frac{r_s}{r_w}} \right]^{-1} \rightarrow \infty \text{ when } S_M \rightarrow -5$$

In other words, the highly negative skin-factor $S_M < -5$ should be modelled as composite area around near-reservoir zones rather than using the concept of Mechanical Skin.

For horizontal wells the lower practical limit when Mechanical Skin concept can be applied is even lower and usually assumed as 0.

See Also

Petroleum Industry / Upstream / Subsurface E&P Disciplines / Well Testing / Pressure Testing

[Well & Reservoir Surveillance][Skin-factor (total)][Skin-factor (geometrical)]