Skin Factor Concept
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"Skin Factor" Concept: (Radial flow system with near-well damage or stimulation)

- Derive the skin factor identity for a well in a radial flow system with a "skin zone" — where the well has near-well damage or stimulation.
- Explain how this model can be used — both in theory and applications.
- Discuss any limitations (physical or conceptual) that you note.

"Skin Factor" Concept Based on:

- Finite thickness model for the radial flow skin factor.
- Effective wellbore radius concept.
Skin Factor: *Finite Thickness Model*

"Finite Thickness" Concept:
- Assumption of a simple 2-zone radial composite reservoir model.
- Steady-state flow is assumed in the "inner-zone" and any other relevant flow regime can exist in the "outer-zone".
Skin Factor: *Finite Thickness Model*

"Finite Thickness" Concept:

- Darcy's law for radial flow.
  \[ v = \frac{qB}{A_r} = \frac{k}{\mu} \frac{dp}{dr} \]

- Cross-sectional area, \( A_r \)
  \[ A_r = 2\pi rh \]

- Substitute, rearrange and integrate across the "skin-zone"
  \[ \int_{r_w}^{r_s} \frac{1}{r} dr = \frac{2\pi klh}{qBm} \int_{p_w^*}^{p_w} dp \]

- Substitute, the permeability of the skin zone, \( k_s \)
  \[ \frac{p_w^*}{p_w} = \frac{1}{141.2} \frac{qBm}{kh} \ln \left[ \frac{r_s}{r_w} \right] \]

- Skin zone pressure drop, \( \Delta p_s = p_w^* - p_w \). Solve for \( \Delta p_s \) and \( s \)
  \[ \Delta p_s = 141.2 \frac{qBm}{kh} \ln \left[ \frac{r_s}{r_w} \right] \frac{k - 1}{k_s} \]

\[ \frac{s}{141.2 \frac{qBm}{kh}} \Delta p_s = \frac{k - 1}{k_s} \ln \left[ \frac{r_s}{r_w} \right] \]
Skin Factor: *Finite Thickness Model*

"Pressure Behavior in a 2-Zone Radial Composite Reservoir":

<table>
<thead>
<tr>
<th>Case</th>
<th>( s )</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k = k_s )</td>
<td>0</td>
<td>No damage or stimulation</td>
</tr>
</tbody>
</table>

\[
ks = \infty -\ln\left(\frac{r_s}{r_w}\right)
\]

Maximum stimulation

\[
k_s = 0 \quad \infty
\]

Maximum stimulation

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[Diagram showing pressure behavior with various cases and comments.]
Skin Factor: Effective Wellbore Radius Concept

"Effective Wellbore Radius" Concept:

- Not based on a physical model.
- Mathematical trick to represent the skin factor as an effective (apparent) wellbore radius.
- This wellbore radius can be used in any radial flow solution to represent the skin factor. (very useful)

\[
P_D(r_0, t_0, \delta') = \frac{1}{2} \ln \left[ \frac{4}{e^8} \frac{t_D}{r_0^2} \right] + \delta'
\]

\[
P_D(r_0, t_D, \delta') = \frac{1}{2} \ln \left[ \frac{4}{e^8} \frac{t_D}{e^{2\delta}} \right]
\]

\[
P_D(r_0, 1, \delta') = \frac{1}{2} \ln \left[ \frac{4}{e^8} \frac{(0.0002687)}{\frac{kt}{\phi_{\mu} \lambda} \left( \frac{1}{\kappa_0 e^{-2\delta}} \right)} \right]
\]

\[r_{wa} = rw e^{-\delta'}\]
Skin Factor: **Effective Wellbore Radius Concept**

"Effective Wellbore Radius" Concept:
- Completely generalizes the skin factor not as a physical pressure drop, but rather as a mathematical identity.