Equations for Cementing flow equations.

From Fann Viscometer

\[ n' = 3.32 \times \left( \log \frac{600 \text{rpm dial reading}'}{300 \text{rpm dial reading}} \right) \]

\[ K' = \frac{N \times (300 \text{rpm dial reading}) \times 1.066}{100 \times 511''} \]

\( N \) = range extension factor of the Fann torque spring.

If viscosity and yield point are known

\[ n' = 3.32 \times \log \left( \frac{2 \mu_p + Y}{\mu_p + Y} \right) \]

\[ K' = \frac{N \times (\mu_p + Y) \times 1.066}{100 \times 511''} \]

\( \mu_p \) = plastic viscosity, cp
\( Y \) = yield point, lb f / 100 ft²

Displacement Velocity

\[ v_d = \frac{17.15 q_b}{d_i^2} = \frac{3.057 q_{cf}}{d_i^2} \]

\( v_d \) = ave. displacement velocity, ft/sec
\( q_b \) = pumping rate, bbl/min
\( q_{cf} \) = pumping rate, ft³/min
\( d_i \) = pipe ID, in

for annulus, \( d_i^2 = d_{iop}^2 - d_{oip}^2 \)
Reynolds number

\[ N_{re} = \frac{1.86v^{(2-n')}}{K'(96/d_i)^n'} \]

\[ \rho = \text{slurry density, lb/gal} \]

for annulus \( d_1 = d_{\text{top}} - d_{\text{oip}} \)

Velocity at which Turbulence Begins \( (N_{re} = 2100) \)

\[ v_c = \left[ \frac{1.129K'\left(96/d_i\right)^{n'}\frac{1}{2-n'}}{\rho} \right] \]

velocity at a given Reynolds number

\[ v_c = \left[ \frac{N_{re}K'\left(96/d_i\right)^{n'}\frac{1}{2-n'}}{1.86\rho} \right] \]

Friction Pressure Drop

\[ \Delta p_f = \frac{0.039L\rho v^2 f}{d_i} \]

\( L = \text{length of pipe, ft} \)
\( f' = \text{Fanning friction factor} \)

Annular area

\[ A = 0.7854\left(d_{\text{so}}^2 - d_{\text{oi}}^2\right) \]