Power Law Rheology Calculations (API units)

Tip: Hover the cursor over parts of the equation to view the variable definitions.

Rheological Equation

$$\tau = K\dot{\gamma}^{n}$$

Flow Behavior Index

$$n = 3.32192809 \log\left(\frac{\theta_{N_2}}{\theta_{N_1}}\right)$$

Consistency Factor

$$K = \frac{510\,\theta_N}{\left(1.703\,N\right)^{n}}$$

Average Velocity in Pipe

$$v_{\mathrm{ap}} = \left(\frac{4}{\pi}\right)\left(\frac{Q}{d_{\mathrm{pi}}^2}\right)$$

Average Velocity in Annulus

$$v_{\mathrm{aa}} = \left(\frac{4}{\pi}\right)\left(\frac{Q}{d_h^2 - d_{\mathrm{po}}^2}\right)$$

Geometry Factor for Annulus

$$G_a = \left[\frac{\left(2n+1\right)}{2n}\right]^{n} 8^{n-1}$$

Geometry Factor for Pipe

$$G_p = \left[\frac{\left(3n+1\right)}{4n}\right]^{n} 8^{n-1}$$

Reynolds Number for Pipe

$$R_p = \frac{\rho v_{\mathrm{ap}}^{\left(2-n\right)}\left(d_{\mathrm{pi}}^{n}\right)}{g_c G_p K}$$

Reynolds Number for Annulus

Critical Reynolds Numbers

$$R_a = \frac{\rho v_{aa}^{\left(2-n\right)} \left(d_h - d_{\text{po}}\right)^n}{g_c \left(\frac{2}{3}\right) G_a K}$$

$$R_l = 3{,}470 - 1{,}370n$$

$$R_t = 4{,}270 - 1{,}370n$$

Friction Factor for Pipe

Laminar flow

$$f_p = \frac{16}{R_p}$$

Transition flow

$$a = \frac{\log\left(n\right) + 3.93}{50}$$

$$b = \frac{1.75 - \log\left(n\right)}{7}$$

$$f_p = \left(\frac{16}{R_l}\right) + \left[\frac{\left(R_p - R_l\right)}{800}\right]\left[\left(\frac{a}{R_t^b}\right) - \left(\frac{16}{R_l}\right)\right]$$

Turbulent flow

$$a = \frac{\log\left(n\right) + 3.93}{50}$$

$$b = \frac{1.75 - \log\left(n\right)}{7}$$

$$f_p = \frac{a}{R_p^b}$$

Friction Factor Annulus

Laminar flow

$$f_a = \frac{24}{R_a}$$

Transition flow

$$a = \frac{\log\left(n\right) + 3.93}{50}$$

$$b = \frac{1.75 - \log\left(n\right)}{7}$$

$$f_a = \left(\frac{24}{R_l}\right) + \left[\frac{\left(R_a - R_l\right)}{800}\right]\left[\left(\frac{a}{R_t^b}\right) - \left(\frac{24}{R_l}\right)\right]$$

Turbulent flow

$$a = \frac{\log\left(n\right) + 3.93}{50}$$

$$b = \frac{1.75 - \log\left(n\right)}{7}$$

$$f_a = \frac{a}{R_a^b}$$

Pressure Loss in Pipe

$$P_{\text{lossp}} = \frac{\rho}{g_c} v_p^2 f_p L_s \left(\frac{2}{d_{\text{pi}}}\right)$$

Pressure Loss in Annulus

$$P_{\text{lossa}} = \frac{\rho}{g_c} v_a^2 f_a L_s \left(\frac{2}{d_h - d_{\text{po}}}\right)$$

Where:

d_h = Annulus diameter

d_{pi} = Pipe inside diameter

d_{po} = Pipe outside diameter

f_a = Friction factor for annulus in turbulent flow

f_p = Friction factor for pipe

G_a = Geometry factor for annulus

G_p = Geometry factor for pipe

g_c= Gravitational constant

K = Consistency factor

L_s = Pipe or annulus section length

N = Fann RPM

n = Flow behavior index

P_{lossa} = Pressure loss in annulus

P_{lossp} = Pressure loss in pipe

Q = Fluid flow rate

R_a = Reynolds number for annulus

R^a_b = Reynolds number for annulus

R_l = Reynolds number at laminar flow boundary

R_p = Reynolds number for pipe

R^b_t = Reynolds number at turbulent flow boundary

v_a = Average fluid velocity for annulus

v_{aa} = Average fluid velocity for annulus

v_{ap} = Average velocity in pipe

v_p = Average fluid velocity for pipe

γ = Shear rate

ρ = Fluid density

τ = Shear stress on walls

θ_N = Fann dial readings corresponding to Fann speed N

$\left(\frac{\theta_{N_2}}{\theta_{N_1}}\right)$
= Fann dial readings corresponding to Fann speed N1 or N2

Related concepts
Hydraulics Analysis Calculation Equations Used