

Darcy friction factor in water producing/injecting wells

@model

Motivation

Assess how [Darcy friction factor](#) is varying along the flow path of water producing/injecting wells

Conclusion

In many engineering applications the [Darcy friction factor](#) in stationary water flow in a constant diameter pipe can be approximated as a constant along hole: $f(l) = f_s = \text{const}$ with absolute value depending on the flowrate q .

The along-hole variation [Darcy friction factor](#) is usually not exceeding 10 % but the contribution of the friction-based pressure loss to the gravity-based pressure build up in vertical and slanted wells is very minor (few percents only) which makes constant [friction factor](#) assumption quite relevant.

The absolute value is staying between $f = 0.04$ for the very small flow rates (< 100 [cmd](#) in 3" pipe) and $f = 0.015$ for the very high flow rates (> 1,000 [cmd](#) in 3" pipe) which makes a substantial difference in slanted and horizontal wells.

For complex well designs with varying pipe flow diameters and water source/stocks which may lead to substantial variation of flowrate the wellbore model can be split in segments each having a constant [friction factor](#).

Derivation

Consider a ratio of along-hole friction-based pressure drop $\left[\frac{dp}{dl}\right]_f = \frac{\rho_s q_s^2}{2A^2 d} f_s$ and gravity-based pressure drop in vertical well $\left[\frac{dp}{dl}\right]_g = \rho_s g$:

$$(1) \quad \frac{[dp/dl]_f}{[dp/dl]_g} = \frac{q_s^2}{2A^2 \cdot d \cdot g} f_s = \frac{f_s u_s^2}{2 \cdot d \cdot g}$$

In 3" tubing with high flowrate (500 m³/d) the flow velocity is going to be around 1.3 m/s and the ratio (1) is going to be $\frac{[dp/dl]_f}{[dp/dl]_g} \sim 3.3\%$.

Furthermore, [Darcy friction factor](#) f for wellbore flow can be written as:

$$(2) \quad \text{Re}(l) = \frac{u(l) \cdot d}{\nu(l)} = \frac{4\rho_s q_s}{\pi d} \frac{1}{\mu(T, p)}$$

The along-hole variation of [Darcy friction factor](#) f is due to the influence of pressure $p(l)$ and temperature $T(l)$ variations on the [fluid viscosity](#) $\mu(T, p)$.

In vertical and slanted wells both temperature and pressure are growing with depth.

The decrease in water [viscosity](#) with growing temperature is partially compensated by decrease in response to growing pressure thus making [viscosity](#) staying within 10% along-hole in most practical cases (usually slightly decreasing with depth).

Providing that friction losses are only 3.3 % of the hydrostatic column the further variation of [Darcy friction factor](#) by 10% provides only 0.33 % error against pressure modelling with constant [Darcy friction factor](#).

In case of slanted wells even a strong inclination will not change the friction contribution by much (may see a slight increase from 3 % up to 5 %).

For the horizontal sections of wells and surface pipelines the value of friction-based pressure loss dominates over vanishing gravity-based pressure build up which zooms the value of accurate calculation of [Darcy friction factor](#) with account of its variation along the flow. In the meantime, for strongly inclined/horizontal pipelines the pressure /temperature variation along the pipe is usually very minor, so is the water [viscosity](#), and [Darcy friction factor](#) again has very little variation along the flow.

See also

[Physics](#) / [Fluid Dynamics](#) / [Pipe Flow Dynamics](#) / [Darcy–Weisbach equation](#) / [Darcy friction factor](#)

[[Fluid friction with pipeline walls](#)] [[Darcy friction factor in water producing/injecting wells @model](#)]