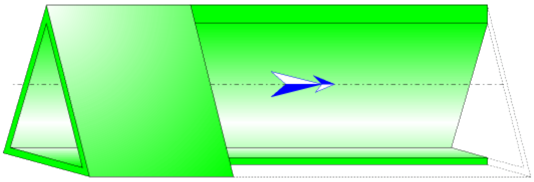
Straight Pipe
Triangular Cross-Section and Smooth Walls
(IDELCHIK)



Model description:

This model of component calculates the major head loss (pressure drop) of a horizontal straight pipe of triangular and constant cross-section.
In addition, the flow is assumed fully developed and stabilized.

The head loss is due to the friction of the fluid on the inner walls of the piping and is calculated with the Darcy formula. The inner wall of the piping is supposed to completely smooth (without roughness).

Darcy friction factor is determined:

- for laminar flow regime by the law of Hagen-Poiseuille,
- for turbulent flow regime by the explicit Filonenko and Althsul equation,
- for critical flow regime by interpolation between friction factors of laminar and turbulent flow.

Model formulation:

Half top angle (°):

$$\beta = \tan^{-1}\left(\frac{a_0}{2 \cdot h}\right)$$

Hydraulic diameter (m):

$$D_h = \frac{2 \cdot h}{1 + \sqrt{\frac{1}{\tan^2(\beta)} + 1}}$$

Cross-section area (m²):

$$F_0 = \frac{a_0}{2} \cdot h$$

Mean velocity (m/s):

$$w_0 = \frac{Q}{F_0}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Fluid volume in the pipe (m^3):

$$V = F_0 \cdot l$$

Fluid mass in the pipe (kg):

$$M = V \cdot \rho$$

Reynolds number:

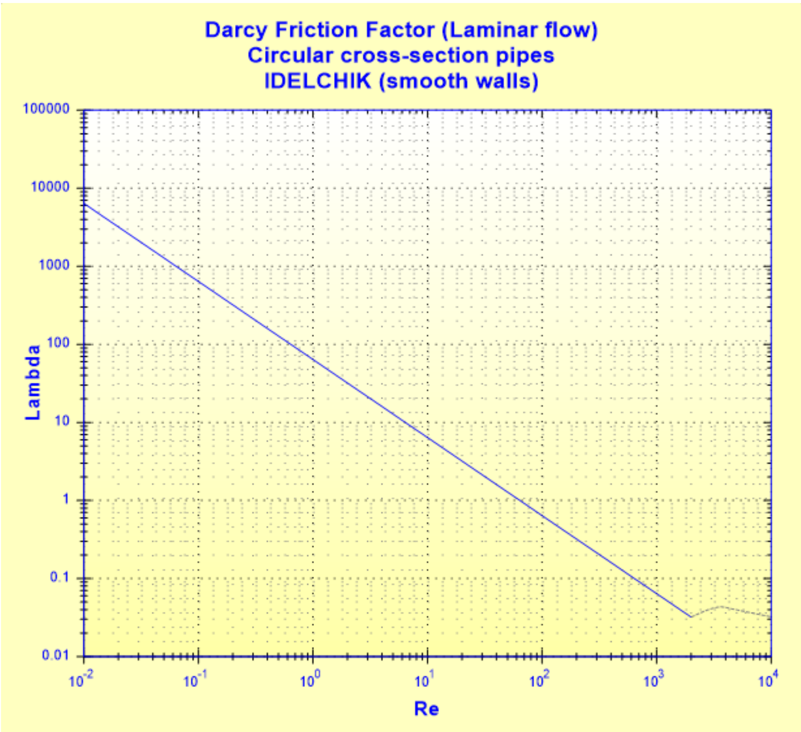
$$\mathrm{Re} = \frac{w_0 \cdot D_h}{\nu}$$

Darcy friction factor for circular cross-section:

- laminar flow regime ($\mathrm{Re} \le 2000$):

  Hagen-Poiseuille law

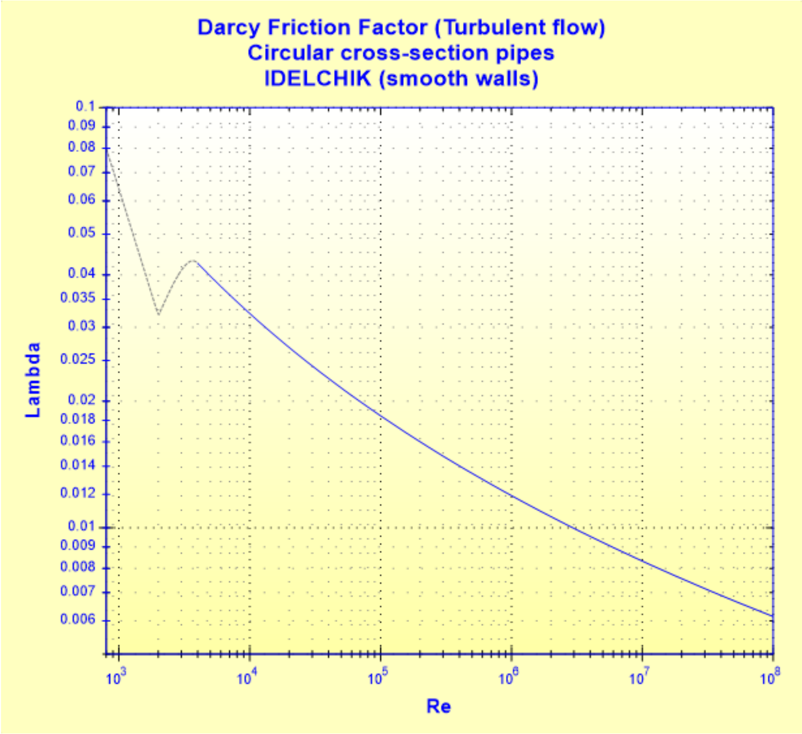
$$\lambda_{circ} = \frac{64}{\mathrm{Re}}$$ ([1] diagram 2.1)



- turbulent flow regime ($\mathrm{Re} \ge 4000$):

  Filonenko and Althsul Equation

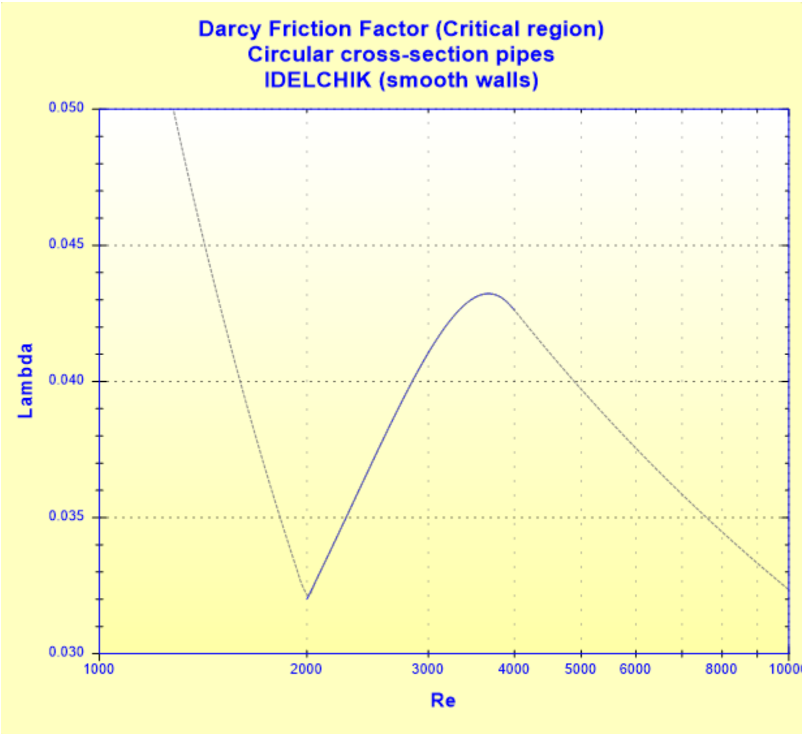
$$\lambda_{circ} = \frac{1}{\left[1.8 \cdot \log(\mathrm{Re}) - 1.64\right]^2}$$ ([1] diagramme 2.1)



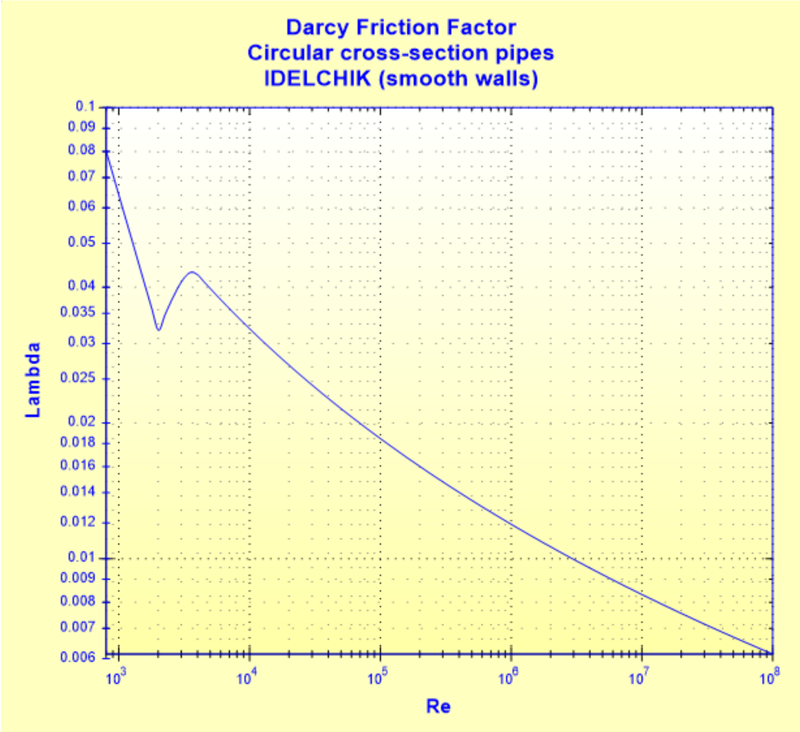
■ critical flow regime (2000 < Re < 4000):

interpolation between laminar and turbulent flows

$\boxed{\lambda_{circ} = f(\mathrm{Re})}$ ([1] diagram 2.1)



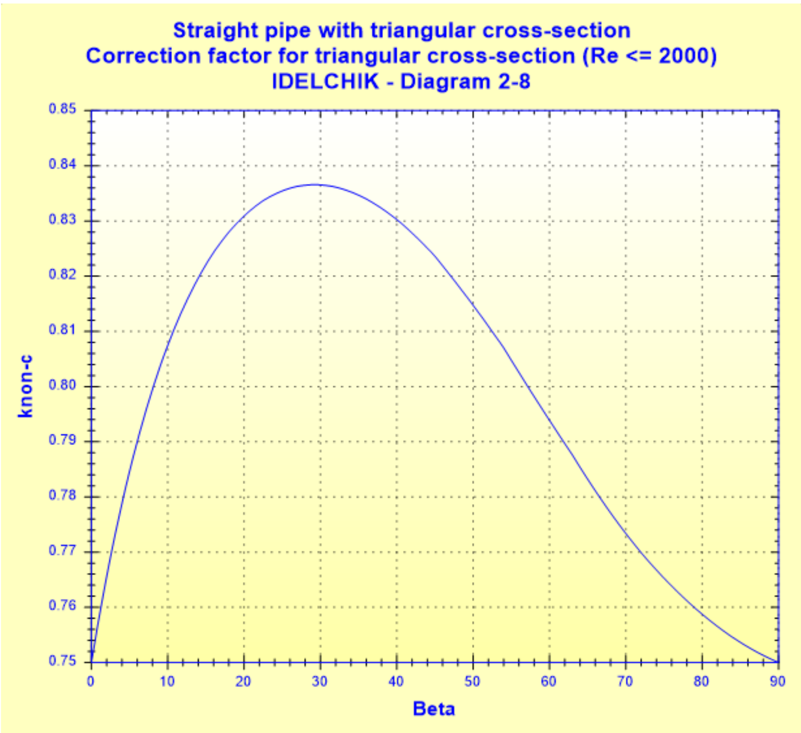
■ all flow regimes:



Correction for Darcy friction factor for triangular cross-section:

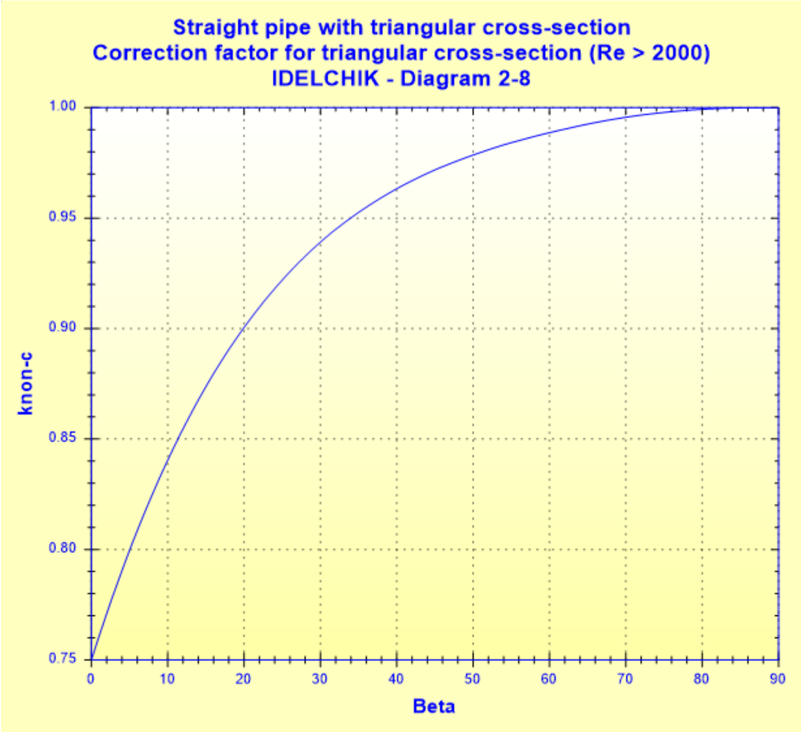
- laminar flow (Re $\le$ 2000):

$$\boxed{k_{non-c} = f(\beta)}$$ ([1] diagram 2.8)



- turbulent flow (Re > 2000):

$$\boxed{k_{non-c} = f(\beta)}$$ ([1] diagram 2.8)



Darcy friction factor for triangular cross-section:

$$\lambda_{tria} = \lambda_{circ} \cdot k_{non-c}$$

([1] diagram 2.8)

Pressure loss coefficient (based on the mean pipe velocity):

$$\zeta = \lambda_{tria} \cdot \frac{l}{D_h}$$

([1] diagram 2.8)

Total pressure loss (Pa):

$$\Delta P = \zeta \cdot \frac{\rho \cdot w_0^2}{2}$$

([1] diagram 2.8)

Total head loss of fluid (m):

$$\Delta H = \zeta \cdot \frac{w_0^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Q$$

Symbols, Definitions, SI Units:

a_0	Cross-section base (m)
h	Cross-section height(m)
β	Half top angle (°)
D_h	Hydraulic diameter (m)
F_0	Cross-sectional area (m²)
Q	Volume flow rate (m³/s)
w_0	Mean velocity (m/s)

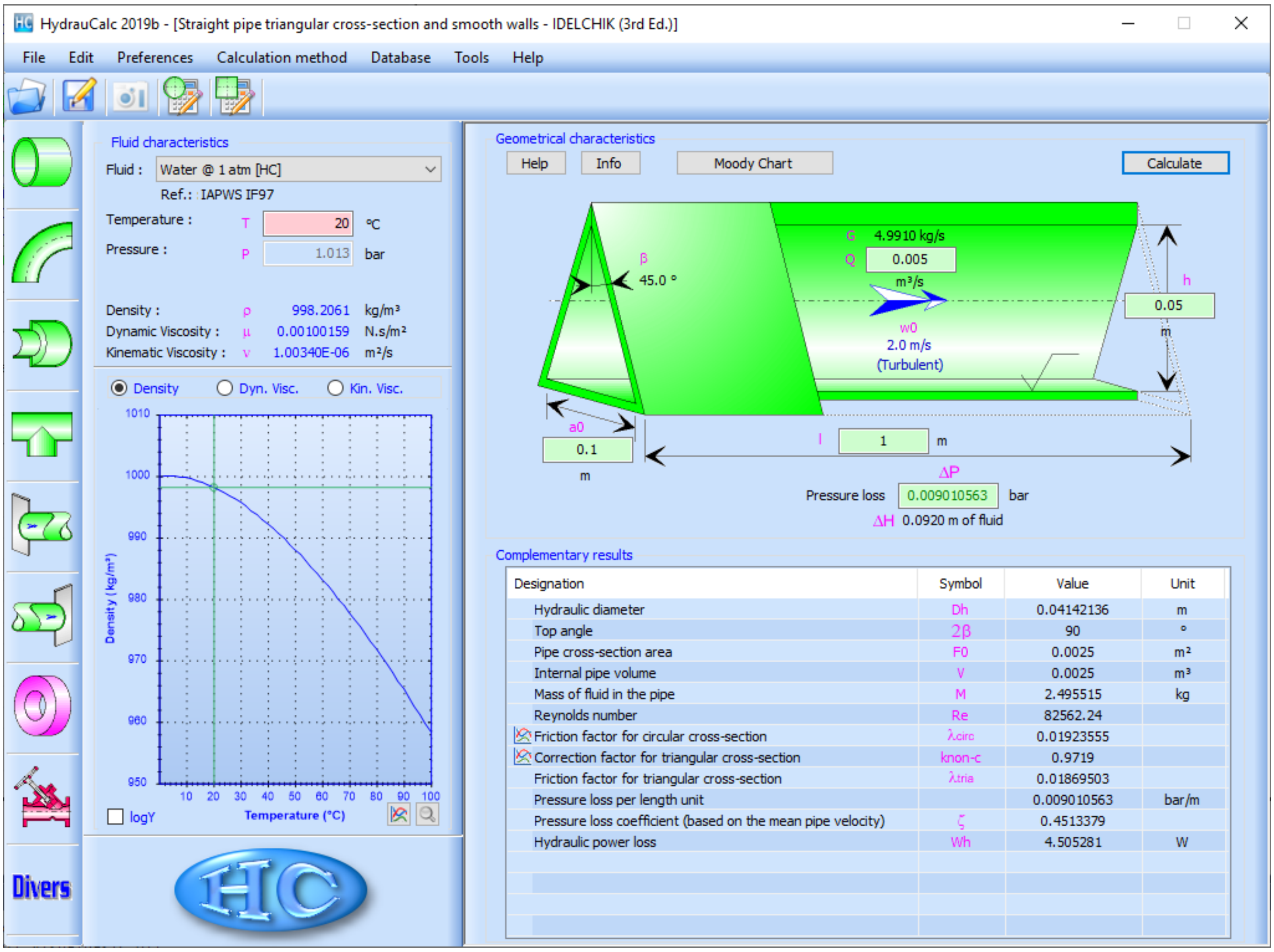
G Mass flow rate (kg/s)
l Pipe length (m)
V Fluid volume in the pipe (m^3)
M Fluid mass in the pipe (kg)
Re Reynolds number ()
λ_{circ} Darcy friction factor for circular cross-section ()
k_{non-c} Correction for Darcy friction factor for noncircular cross-section ()
λ_{tria} Darcy friction factor for triangular cross-section ()
ζ Pressure loss coefficient (based on the mean pipe velocity) ()
ΔP Total pressure loss (Pa)
ΔH Total head loss of fluid (m)
Wh Hydraulic power loss (W)

ρ Fluid density (kg/m^3)
ν Fluid kinematic viscosity (m^2/s)
g Gravitational acceleration (m/s^2)

Validity range:

- any flow regime: laminar, critical and turbulent ($Re \leq 10^8$)
- stabilized flow

Example of input data and results:



References:

[1] Handbook of Hydraulic Resistance, 3rd Edition, I.E. Idelchik (2008)