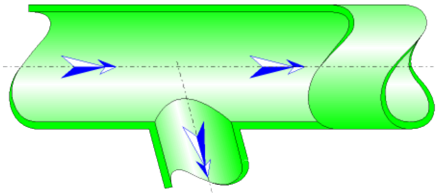
Dividing sharp-edged junction
Circular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a dividing sharp-edged junction.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Cross-sectional area of the lateral branch (m^2):

$$F_s = \pi \cdot \frac{D_s^2}{4}$$

Cross-sectional area of the common branch and the straight branch (m^2):

$$F_c = \pi \cdot \frac{D_c^2}{4}$$

Volume flow rate in the common branch (m^3/s):

$$Q_c = Q_s + Q_{st}$$

Mean velocity in the lateral branch (m/s):

$$w_s = \frac{Q_s}{F_s}$$

Mean velocity in the straight branch (m/s):

$$w_{st} = \frac{Q_{st}}{F_c}$$

Mean velocity in the common branch (m/s):

$$w_c = \frac{Q_c}{F_c}$$

Mass flow rate in the lateral branch (kg/s):

$$G_s = Q_s \cdot \rho$$

Mass flow rate in the straight branch (kg/s):

$$G_{st} = Q_{st} \cdot \rho$$

Mass flow rate in the common branch (kg/s):

$$G_c = Q_c \cdot \rho$$

Reynolds number in the lateral branch:

$$\mathrm{Re}_s = \frac{w_s \cdot D_s}{\nu}$$

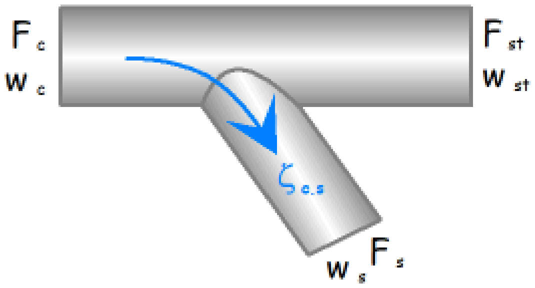
Reynolds number in the straight branch:

$$\mathrm{Re}_{st} = \frac{w_{st} \cdot D_c}{\nu}$$

Reynolds number in the common branch:

$$\mathrm{Re}_c = \frac{w_c \cdot D_c}{\nu}$$

Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch):



■ $\mathrm{Re}_c \geq 4000$

$$\zeta_{c.s} = A' \cdot \zeta'_{c.s}$$ ([1] diagram 7-18)

with:

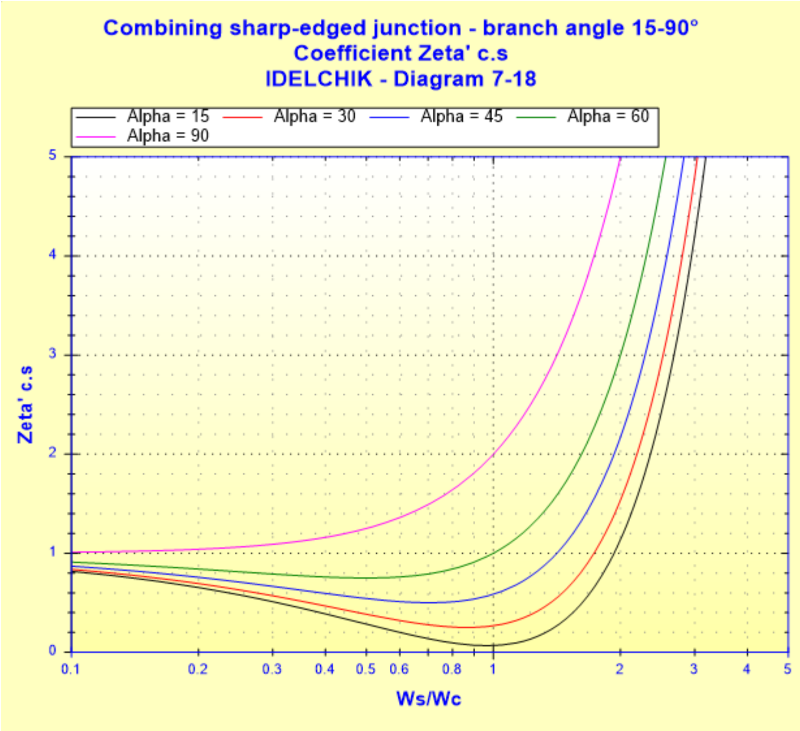
Values of A'

F_s / F_c	≤ 0.35		> 0.35	
Q_s / Q_c	≤ 0.4	> 0.4	≤ 0.6	> 0.6
A'	$1.1 - 0.7 \cdot \frac{Q_s}{Q_c}$	0.85	$1.0 - 0.6 \cdot \frac{Q_s}{Q_c}$	0.6

([1] table 7-4)

$$\boxed{\zeta'_{c.s} = 1 + \left(\frac{w_s}{w_c}\right)^2 - 2 \cdot \left(\frac{w_s}{w_c}\right) \cdot \cos(\alpha)}$$

([1] diagram 7-18)



■ $Re_c \leq 2000$

$$\boxed{\zeta_{c.s} = (k_1 + 1) \cdot \zeta^t{}_{c.s} + \frac{150}{Re_c}}$$

([1] equation §31)

with:

Values of k_1

Q_s/Q_c	Alpha			
	30°	45°	60°	90°
0	0.9	0.9	0.9	0.9
0.2	1.8	1.8	1.5	1.1
0.4	3.4	2.9	2.2	1.3
0.6	6.1	4.3	3	1.5
0.8	7.2	4.3	2.7	1.4
1	6	3.6	2.3	1.3

([1] table 7-7)

$$\boxed{\zeta^t{}_{c.s} = A' \cdot \left[1 + \left(\frac{w_s}{w_c}\right)^2 - 2 \cdot \frac{w_s}{w_c} \cdot \cos(\alpha)\right] - K'_{st} \cdot \left(\frac{w_s}{w_c}\right)^2}$$

([1] equation 7.3)

with:

Values of A'

F_s / F_c	≤ 0.35		> 0.35	
Q_s / Q_c	≤ 0.4	> 0.4	≤ 0.6	> 0.6
A'	$1.1 - 0.7 \cdot \frac{Q_s}{Q_c}$	0.85	$1.0 - 0.6 \cdot \frac{Q_s}{Q_c}$	0.6

([1] table 7-4)

$$\boxed{K'_{st} = 0}$$

- $2000 < Re_c < 4000$

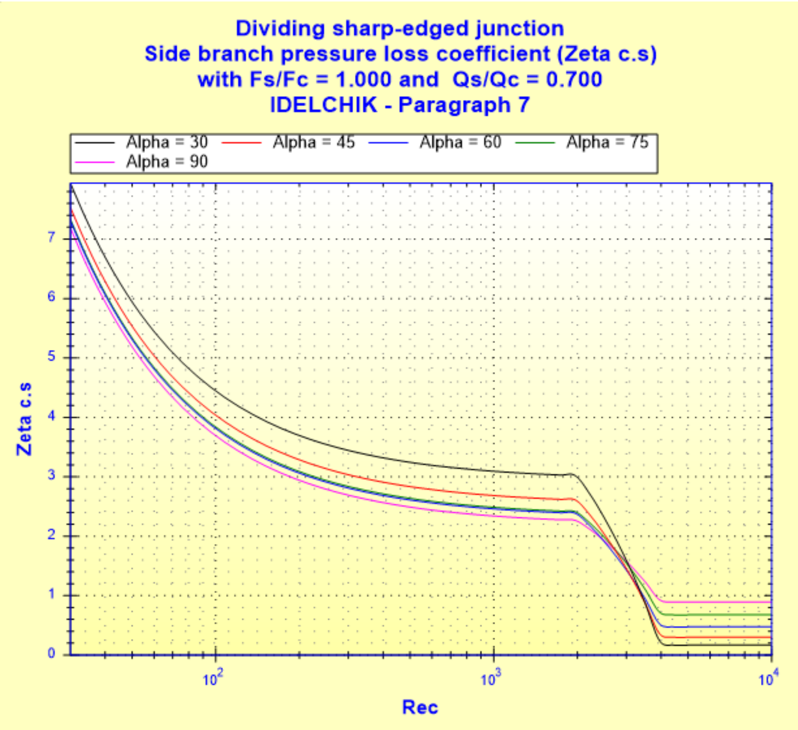
linear interpolation

$$\boxed{\zeta_{c.s} = \zeta^{l}_{c.s} \cdot \left(1 - \frac{Re_c - 2000}{2000}\right) + \zeta^{t}_{c.s} \cdot \left(\frac{Re_c - 2000}{2000}\right)}$$

with:

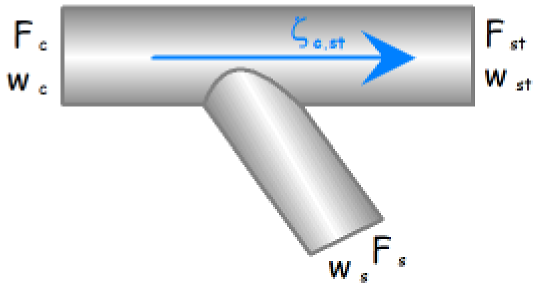
$\zeta^{l}_{c.s}$ = laminar coefficient obtained with $Re_c = 2000$

$\zeta^{t}_{c.s}$ = turbulent coefficient obtained with $Re_c = 4000$



$\zeta_{c.s}$ for $Re_c < 4000$ and with $F_s/F_c = 1$ and $Q_s/Q_c = 0.7$

Pressure loss coefficient of the straight branch (based on mean velocity in the common branch):



■ $Re_c \geq 4000$

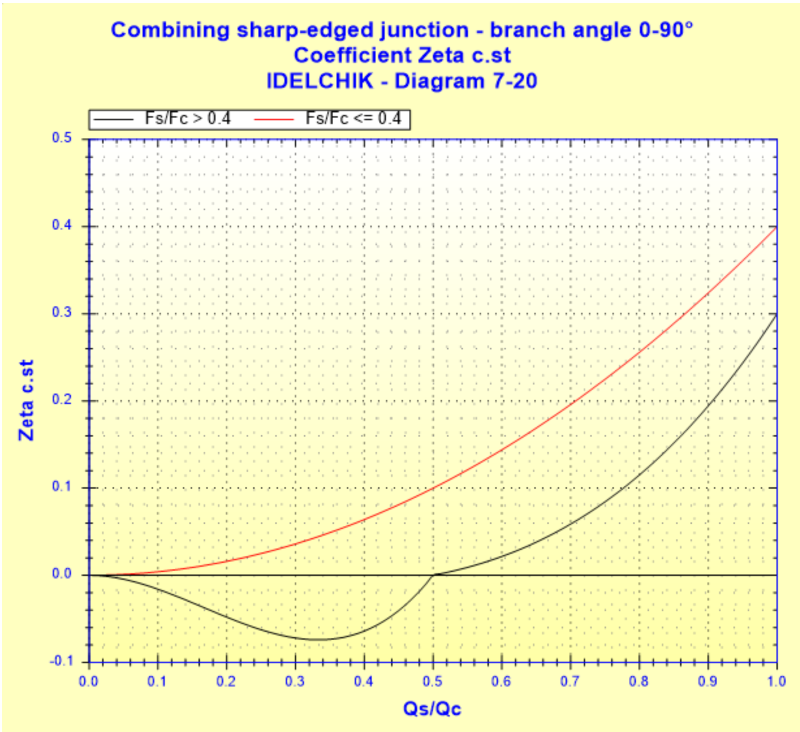
$$\boxed{\zeta_{c.st} = \tau_{st} \cdot \left(\frac{Q_s}{Q_c}\right)^2}$$ ([1] diagram 7-20)

with:

Values of τ_{st}

F_s / F_c	≤ 0.4	> 0.4	
Q_s / Q_c	0 - 1.0	≤ 0.5	> 0.5
τ_{st}	0.4	$2 \cdot \left(2 \cdot \frac{Q_s}{Q_c} - 1\right)$	$0.3 \cdot \left(2 \cdot \frac{Q_s}{Q_c} - 1\right)$

([1] diagram 7-20)



■ $Re_c \leq 2000$

$$\boxed{\zeta_{c.st} = 3 \cdot \zeta^t{}_{c.st} + \frac{33}{Re_c}}$$ ([1] equation §31)

with:

$$\boxed{\zeta^t{}_{c.st} = \tau_{st} \cdot \left(\frac{Q_s}{Q_c}\right)^2}$$ ([1] equation 7-4)

with:

Values of τ_{st}

F_s / F_c	≤ 0.4	> 0.4	
Q_s / Q_c	0 - 1.0	≤ 0.5	> 0.5
τ_{st}	0.4	$2 \cdot \left(2 \cdot \frac{Q_s}{Q_c} - 1\right)$	$0.3 \cdot \left(2 \cdot \frac{Q_s}{Q_c} - 1\right)$

([1] diagram 7-20)

- $2000 < Re_c < 4000$

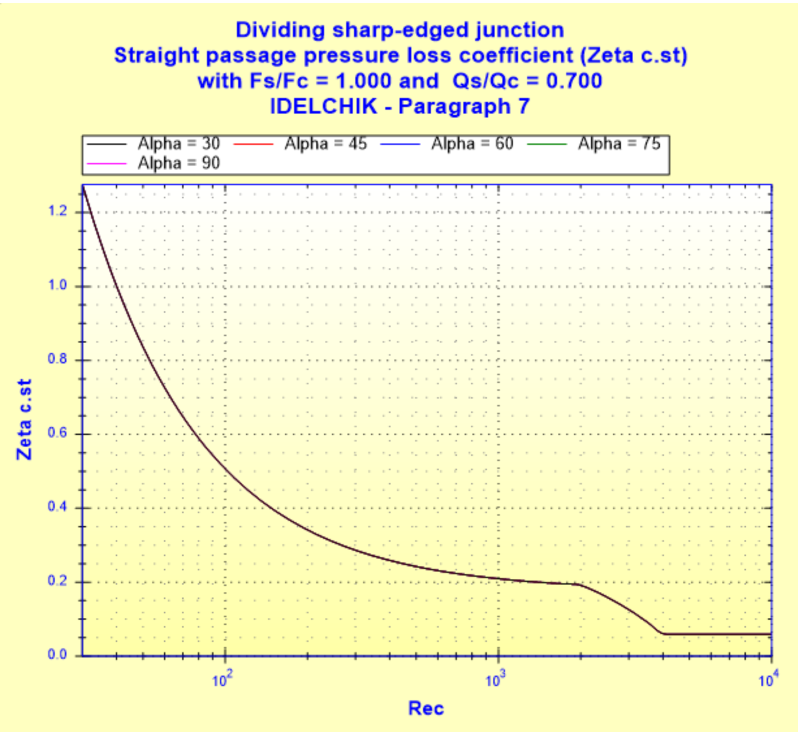
linear interpolation

$$\zeta_{c.st} = \zeta^{l}{}_{c.st} \cdot \left(1 - \frac{Re_c - 2000}{2000}\right) + \zeta^{t}{}_{c.st} \cdot \left(\frac{Re_c - 2000}{2000}\right)$$

with:

$\zeta^{l}{}_{c.st}$ = laminar coefficient obtained with Re_c = 2000

$\zeta^{t}{}_{c.st}$ = turbulent coefficient obtained with Re_c = 4000



$\zeta_{c.st}$ for $Re_c < 4000$ and with $F_s/F_c = 1$ and $Q_s/Q_c = 0.7$

Pressure loss in the lateral branch (Pa):

$$\Delta P_{c.s} = \zeta_{c.s} \cdot \frac{\rho \cdot w_c^2}{2}$$

Pressure loss in the straight branch (Pa):

$$\Delta P_{c.st} = \zeta_{c.st} \cdot \frac{\rho \cdot w_c^2}{2}$$

Head loss of fluid in the lateral branch (m):

$$\Delta H_{c.s} = \zeta_{c.s} \cdot \frac{w_c^{\ 2}}{2 \cdot g}$$

Head loss of fluid in the straight branch (m):

$$\Delta H_{c.st} = \zeta_{c.st} \cdot \frac{w_c^{\ 2}}{2 \cdot g}$$

Hydraulic power loss in the lateral branch (W):

$$Wh_s = \Delta P_{c.s} \cdot Q_s$$

Hydraulic power loss in the straight branch (W):

$$Wh_{st} = \Delta P_{c.st} \cdot Q_{st}$$

Symbols, Definitions, SI Units:

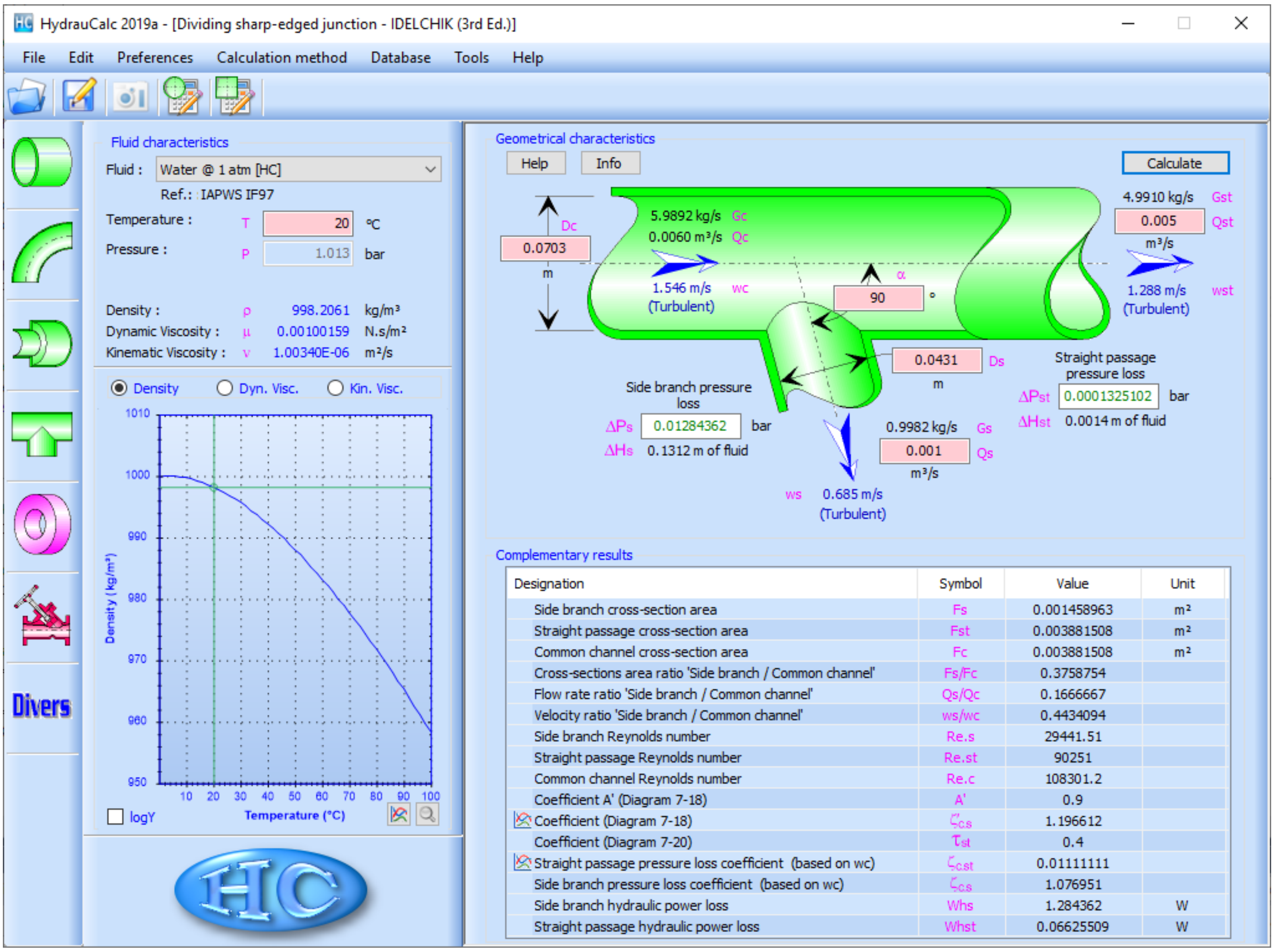
D_s	Diameter of the lateral branch (m)
D_c	Diameter of the common branch and the straight branch (m)
F_s	Cross-sectional area of the lateral branch (m²)
F_c	Cross-sectional area of the common branch and the straight branch (m²)
Q_s	Volume flow rate in the lateral branch (m³/s)
w_s	Mean velocity in the lateral branch (m/s)
Q_{st}	Volume flow rate in the straight branch (m³/s)
w_{st}	Mean velocity in the straight branch (m/s)
Q_c	Volume flow rate in the common branch (m³/s)
w_c	Mean velocity in the common branch (m/s)
G_s	Mass flow rate in the lateral branch (kg/s)
G_{st}	Mass flow rate in the straight branch (kg/s)
G_c	Mass flow rate in the common branch (kg/s)
Re_s	Reynolds number in the lateral branch ()
Re_{st}	Reynolds number in the straight branch ()
Re_c	Reynolds number in the common branch ()
α	Angle of the lateral branch (m)
$\zeta^l_{c.s}$	Pressure loss coefficient of the lateral branch in laminar flow ()
$\zeta^t_{c.st}$	Pressure loss coefficient of the straight branch in turbulent flow ()
$\zeta_{c.s}$	Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch) ()
$\zeta_{c.st}$	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
ΔP_s	Pressure loss in the lateral branch (Pa)
ΔP_{st}	Pressure loss in the straight branch (Pa)
ΔH_s	Head loss of fluid in the lateral branch (m)
ΔH_{st}	Head loss of fluid in the straight branch (m)
Wh_s	Hydraulic power loss in the lateral branch (W)
Wh_{st}	Hydraulic power loss in the straight branch (W)
ρ	Fluid density (kg/m³)

ν Fluid kinematic viscosity (m^2/s)
g Gravitational acceleration (m/s^2)

Validity range:

- angle of the lateral branch: between 30° and 90°

Example of application:



References:

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