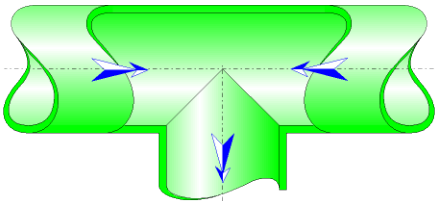
Symmetric combining sharp-edged T-junction
Circular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a symmetric combining sharp-edged T-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 right branch (m²):

$$F_{1s} = \pi \cdot \frac{D_s^2}{4}$$

Cross-sectional area of the left branch (m²):

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

Cross-sectional area of the common branch (m²):

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

Volume flow rate in the common branch (m³/s):

$$Q_c = Q_{1s} + Q_{2s}$$

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

$$w_{1s} = \frac{Q_{1s}}{F_{1s}}$$

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

$$w_{2s} = \frac{Q_{2s}}{F_{2s}}$$

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

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

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

$$G_{1s} = Q_{1s} \cdot \rho$$

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

$$G_{2s} = Q_{2s} \cdot \rho$$

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

$$G_c = Q_c \cdot \rho$$

Reynolds number in the right branch:

$$\mathrm{Re}_{1s} = \frac{w_{1s} \cdot D_s}{\nu}$$

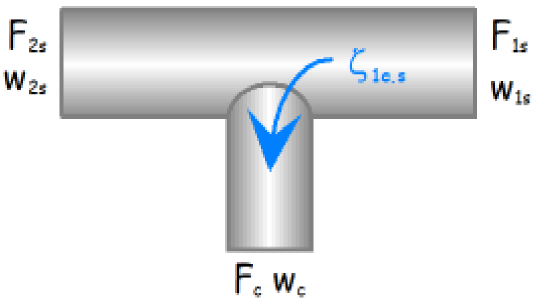
Reynolds number in the left branch:

$$\mathrm{Re}_{2s} = \frac{w_{2s} \cdot D_s}{\nu}$$

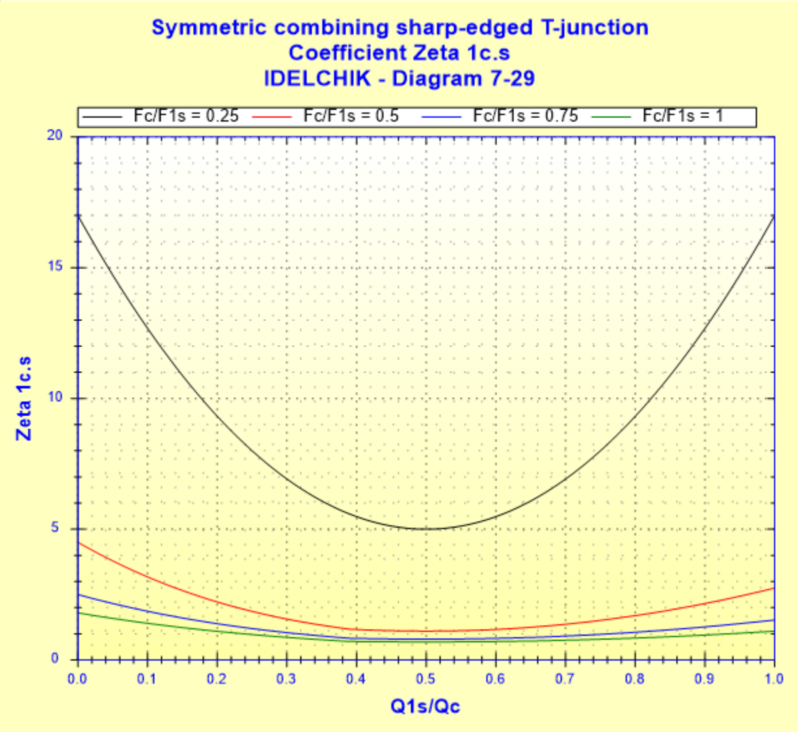
Reynolds number in the common branch:

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

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



$$\zeta_{1c.s} = A_{1s} \cdot \zeta'_{1c.s}$$ ([1] diagram 7.29 – Merging of streams without partition)



with:

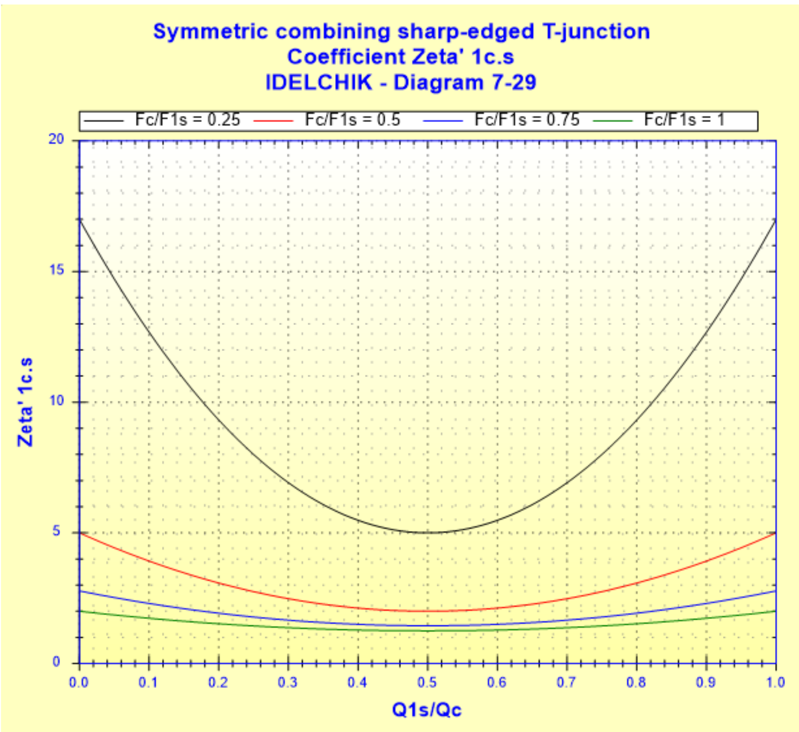
Values of A_{1s}

F_{1s} / F_c	≤ 0.35	> 0.35	
Q_{1s} / Q_c	≤ 1	≤ 0.4	> 0.4
A_{1s}	1	$0.9 \cdot \left(1 - \frac{Q_{1s}}{Q_c}\right)$	0.55

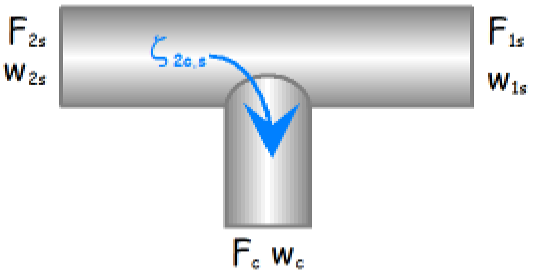
([1] table 7-1)

$$\zeta'_{1c.s} = 1 + \left(\frac{F_c}{F_{1s}}\right)^2 + 3 \cdot \left(\frac{F_c}{F_{1s}}\right)^2 \cdot \left[\left(\frac{Q_{1s}}{Q_c}\right)^2 - \left(\frac{Q_{1s}}{Q_c}\right)\right]$$

([1] diagram 7.29)

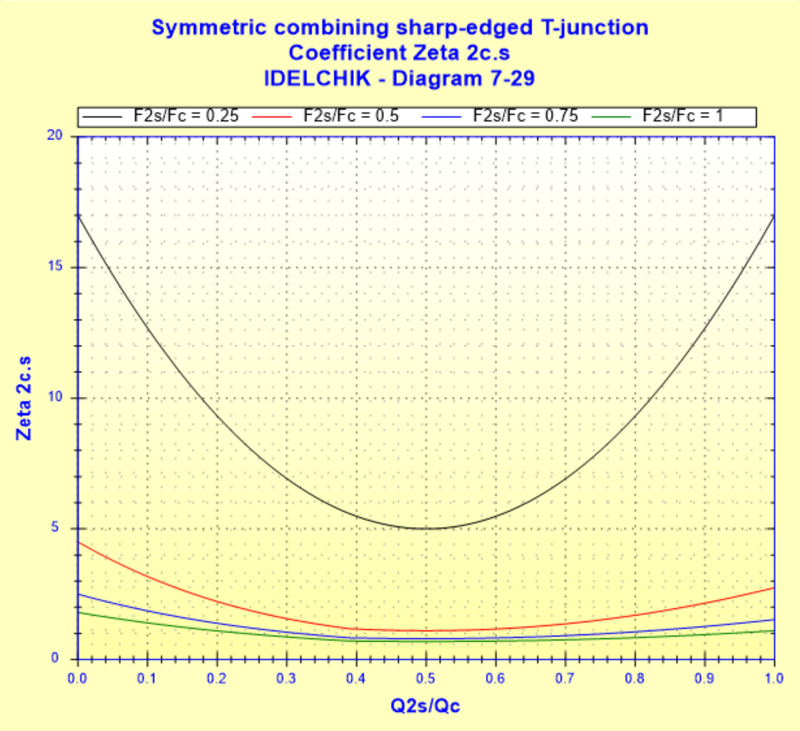


Pressure loss coefficient of the left branch (based on mean velocity in the common branch):



Note: for the left branch, the formulas are the same as those of the right branch, with subscript 2 instead of subscript 1.

$$\boxed{\zeta_{2c.s} = A_{2s} \cdot \zeta'_{2c.s}}$$ ([1] diagram 7.29 – Merging of streams without partition)



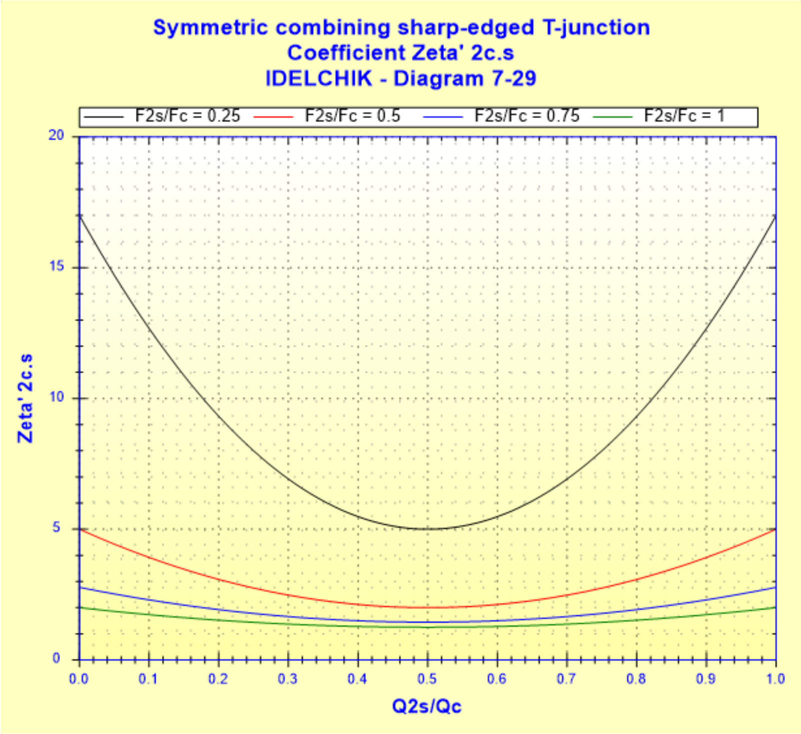
with:

Values of A_{2s}

F_{2s} / F_c	≤ 0.35	> 0.35	
Q_{2s} / Q_c	≤ 1	≤ 0.4	> 0.4
A_{2s}	1	$0.9 \cdot \left(1 - \frac{Q_{2s}}{Q_c}\right)$	0.55

([1] table 7-1)

$$\boxed{\zeta'_{2c.s} = 1 + \left(\frac{F_c}{F_{2s}}\right)^2 + 3 \cdot \left(\frac{F_c}{F_{2s}}\right)^2 \cdot \left[\left(\frac{Q_{2s}}{Q_c}\right)^2 - \left(\frac{Q_{2s}}{Q_c}\right)\right]}$$ ([1] diagram 7.29)



Pressure loss in the right branch (Pa):

$$\Delta P_{1c.s} = \zeta_{1c.s} \cdot \frac{\rho \cdot w_c^{\ 2}}{2}$$

Pressure loss in the left branch (Pa):

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

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

$$\Delta H_{1c.s} = \zeta_{1c.s} \cdot \frac{w_c^{\ 2}}{2 \cdot g}$$

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

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

Hydraulic power loss in the right branch (W):

$$Wh_{1s} = \Delta P_{1c.s} \cdot Q_{1s}$$

Hydraulic power loss in the left branch (W):

$$Wh_{2s} = \Delta P_{2c.s} \cdot Q_{2s}$$

Symbols, Definitions, SI Units:

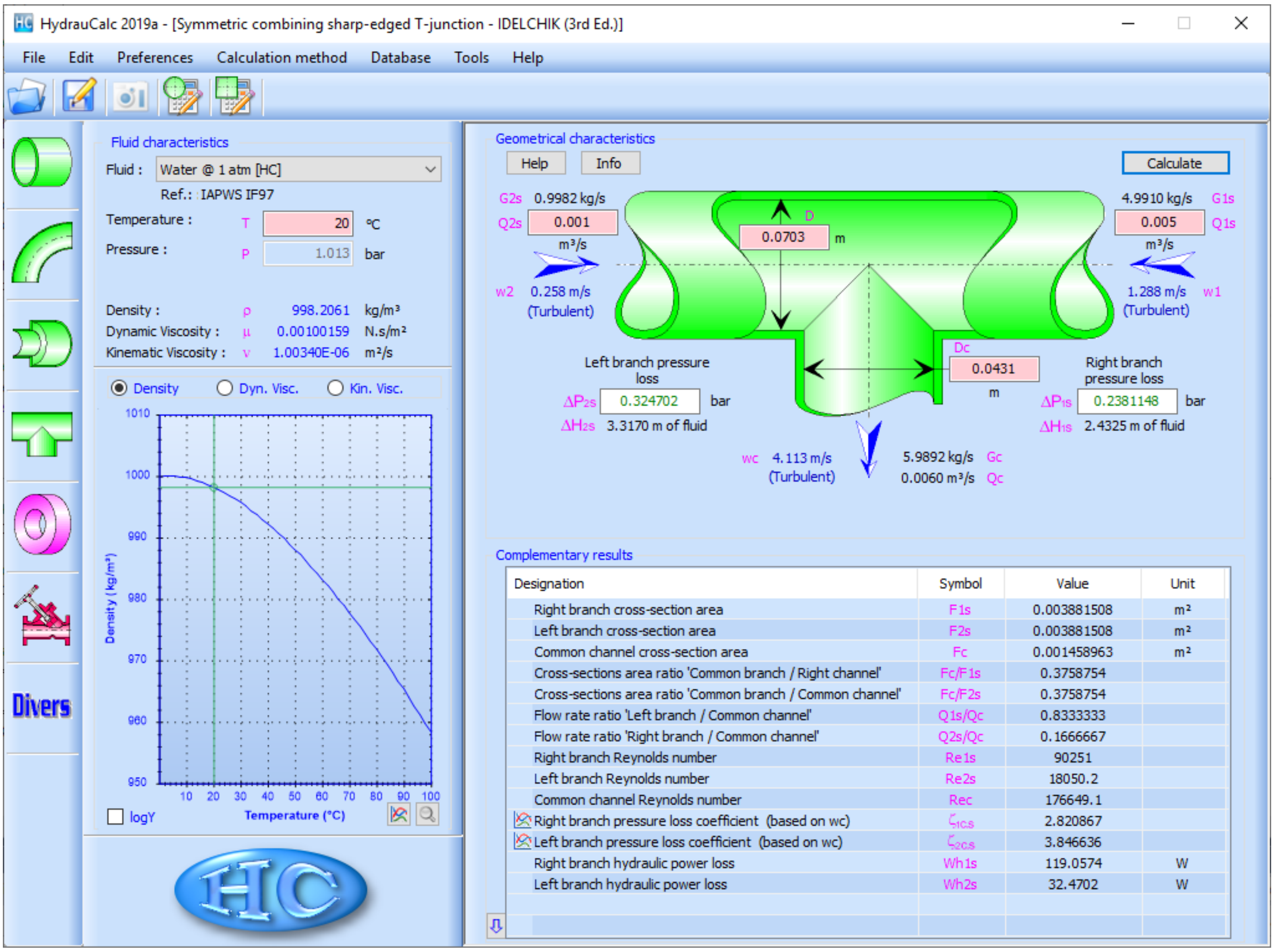
D_s	Diameter of the right and left branches (m)
D_c	Diameter of the common branch (m)
F_{1s}	Cross-sectional area of the right branch (m^2)

F_{2s}	Cross-sectional area of the left branch (m^2)
F_c	Cross-sectional area of the common branch (m^2)
Q_{1s}	Volume flow rate in the right branch (m^3/s)
w_{1s}	Mean velocity in the right branch (m/s)
Q_{2s}	Volume flow rate in the left branch (m^3/s)
w_{2s}	Mean velocity in the left branch (m/s)
Q_c	Volume flow rate in the common branch (m^3/s)
w_c	Mean velocity in the common branch (m/s)
G_{1s}	Mass flow rate in the right branch (kg/s)
G_{2s}	Mass flow rate in the left branch (kg/s)
G_c	Mass flow rate in the common branch (kg/s)
Re_{1s}	Reynolds number in the right branch ()
Re_{2s}	Reynolds number in the left branch ()
Re_c	Reynolds number in the common branch ()
$\zeta_{1c.s}$	Pressure loss coefficient of the right branch (based on mean velocity in the common branch) ()
$\zeta_{2c.s}$	Pressure loss coefficient of the left branch (based on mean velocity in the common branch) ()
ΔP_{1s}	Pressure loss in the right branch (Pa)
ΔP_{2s}	Pressure loss in the left branch (Pa)
ΔH_{1s}	Head loss of fluid in the right branch (m)
ΔH_{2s}	Head loss of fluid in the left branch (m)
Wh_{1s}	Hydraulic power loss in the right branch (W)
Wh_{2s}	Hydraulic power loss in the left branch (W)
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Validity range:

- turbulent flow regime ($Re_c \geq 10^4$)
- diameter of common branch (D_c) ≤ diameter of right and left branches (D_s)

Example of application:



Designation	Symbol	Value	Unit
Right branch cross-section area	F1s	0.003881508	m²
Left branch cross-section area	F2s	0.003881508	m²
Common channel cross-section area	Fc	0.001458963	m²
Cross-sections area ratio 'Common branch / Right channel'	Fc/F1s	0.3758754	
Cross-sections area ratio 'Common branch / Common channel'	Fc/F2s	0.3758754	
Flow rate ratio 'Left branch / Common channel'	Q1s/Qc	0.8333333	
Flow rate ratio 'Right branch / Common channel'	Q2s/Qc	0.1666667	
Right branch Reynolds number	Re1s	90251	
Left branch Reynolds number	Re2s	18050.2	
Common channel Reynolds number	Rec	176649.1	
Right branch pressure loss coefficient (based on wc)	ζ1cs	2.820867	
Left branch pressure loss coefficient (based on wc)	ζ2cs	3.846636	
Right branch hydraulic power loss	Wh1s	119.0574	W
Left branch hydraulic power loss	Wh2s	32.4702	W

References:

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