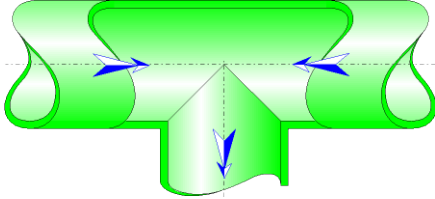




Symmetric combining sharp-edged T-junction Circular Cross-Section (MILLER)



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 with three legs of equal area.

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 three branches (m^2):

$$A_1 = \pi \cdot \frac{D_1^2}{4}$$

$$A_2 = \pi \cdot \frac{D_2^2}{4}$$

$$A_3 = \pi \cdot \frac{D_3^2}{4}$$

with $D_1 = D_2 = D_3$

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

$$Q_3 = Q_1 + Q_2$$

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

$$U_1 = \frac{Q_1}{A_1}$$

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

$$U_2 = \frac{Q_2}{A_2}$$

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

$$U_3 = \frac{Q_3}{A_3}$$

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

$$G_1 = Q_1 \cdot \rho$$

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

$$G_2 = Q_2 \cdot \rho$$

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

$$G_3 = Q_3 \cdot \rho$$

Reynolds number in the left branch:

$$Re_1 = \frac{U_1 \cdot D_1}{\nu}$$

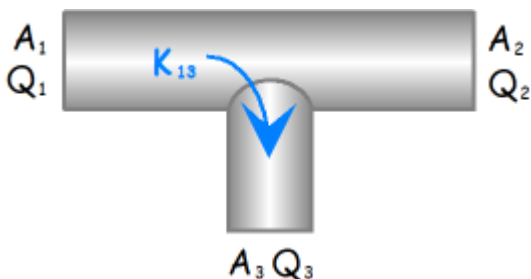
Reynolds number in the right branch:

$$Re_2 = \frac{U_2 \cdot D_2}{\nu}$$

Reynolds number in the common branch:

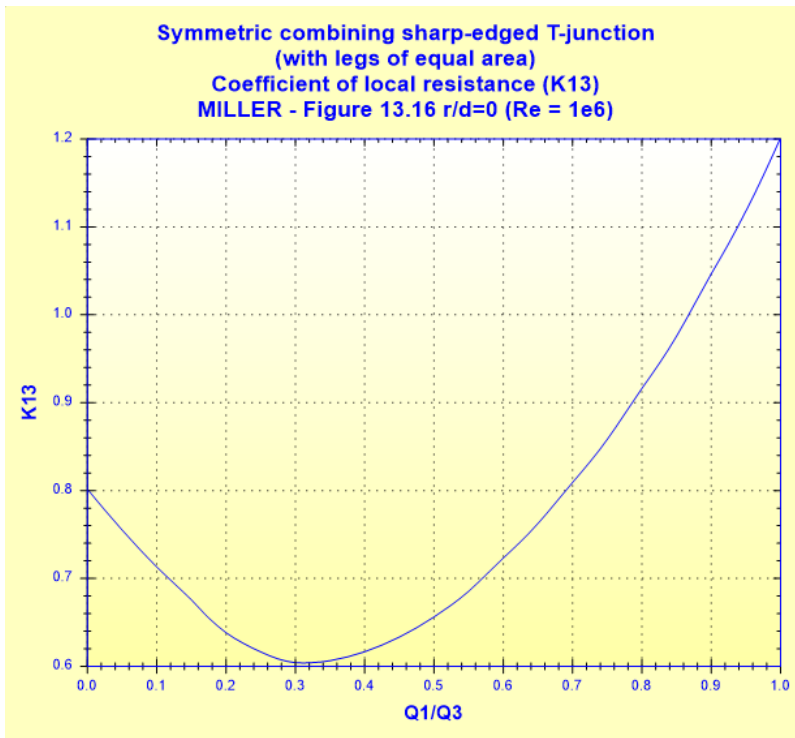
$$Re_3 = \frac{U_3 \cdot D_3}{\nu}$$

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

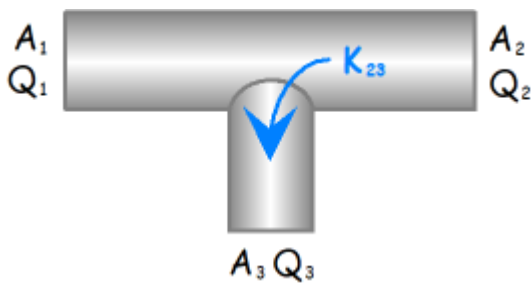


$$K_{13} = f \left(\frac{Q_1}{Q_3} \right)$$

([1] figure 13.16 with $r/d = 0$)

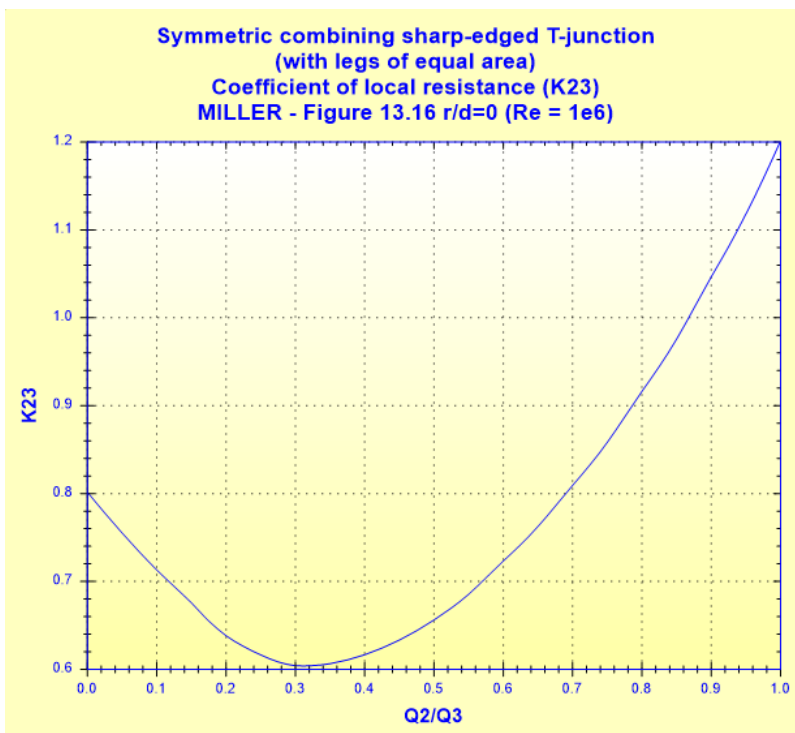


Pressure loss coefficient of the right branch (based on mean velocity in the common branch):



$$K_{23} = f\left(\frac{Q_2}{Q_3}\right)$$

([1] figure 13.16 with r/d = 0)



Pressure loss in the left branch (Pa):

$$\Delta P_{13} = K_{13} \cdot \frac{\rho \cdot U_3^2}{2} \quad ([1] \text{ equation 13.1})$$

Pressure loss in the right branch (Pa):

$$\Delta P_{23} = K_{23} \cdot \frac{\rho \cdot U_3^2}{2} \quad ([1] \text{ equation 13.2})$$

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

$$\Delta H_{13} = K_{13} \cdot \frac{U_3^2}{2 \cdot g}$$

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

$$\Delta H_{23} = K_{23} \cdot \frac{U_3^2}{2 \cdot g}$$

Hydraulic power loss in the left branch (W):

$$Wh_{13} = \Delta P_{13} \cdot Q_1$$

Hydraulic power loss in the right branch (W):

$$Wh_{23} = \Delta P_{23} \cdot Q_2$$

Symbols, Definitions, SI Units:

D_1	Diameter of the left branch (m)
D_2	Diameter of the right branch (m)
D_3	Diameter of the common branch (m)
A_1	Cross-sectional area of the left branch (m ²)
A_2	Cross-sectional area of the right branch (m ²)
A_3	Cross-sectional area of the common branch (m ²)
Q_1	Volume flow rate in the left branch (m ³ /s)
U_1	Mean velocity in the left branch (m/s)
Q_2	Volume flow rate in the right branch (m ³ /s)
U_2	Mean velocity in the right branch (m/s)
Q_3	Volume flow rate in the common branch (m ³ /s)
U_3	Mean velocity in the common branch (m/s)
G_1	Mass flow rate in the left branch (kg/s)
G_2	Mass flow rate in the right branch (kg/s)
G_3	Mass flow rate in the common branch (kg/s)
Re_1	Reynolds number in the left branch ()
Re_2	Reynolds number in the right branch ()
Re_3	Reynolds number in the common branch ()

- K_{13} Pressure loss coefficient of the left branch (based on mean velocity in the common branch) ()
 K_{23} Pressure loss coefficient of the right branch (based on mean velocity in the common branch) ()
 ΔP_{13} Pressure loss in the left branch (Pa)
 ΔP_{23} Pressure loss in the right branch (Pa)
 ΔH_{13} Head loss of fluid in the left branch (m)
 ΔH_{23} Head loss of fluid in the right branch (m)
 Wh_{13} Hydraulic power loss in the left branch (W)
 Wh_{23} Hydraulic power loss in the right 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 ($Re_3 \geq 10^5$)
- three legs of equal area

Example of application:

The screenshot shows the HydraulCalc 2019a software interface for a symmetric combining sharp-edged T-junction. The fluid is Water @ 1 atm [HC] with a temperature of 20 °C and a pressure of 1.013 bar. The fluid characteristics are: Density $\rho = 998.2061 \text{ kg/m}^3$, Dynamic Viscosity $\mu = 0.00100159 \text{ N.s/m}^2$, and Kinematic Viscosity $\nu = 1.00340E-06 \text{ m}^2/\text{s}$. The geometrical characteristics include flow rates $G1 = 0.9982 \text{ kg/s}$, $G2 = 4.9910 \text{ kg/s}$, and $G3 = 5.9892 \text{ kg/s}$; flow rates $Q1 = 0.001 \text{ m}^3/\text{s}$, $Q2 = 0.005 \text{ m}^3/\text{s}$, and $Q3 = 0.006 \text{ m}^3/\text{s}$; and velocities $U1 = 0.258 \text{ m/s}$ (Turbulent), $U2 = 1.288 \text{ m/s}$ (Turbulent), and $U3 = 1.546 \text{ m/s}$ (Turbulent). The pressure losses are $\Delta P_{13} = 0.007888462 \text{ bar}$ and $\Delta P_{23} = 0.01138594 \text{ bar}$. The head losses are $\Delta H_{13} = 0.0806 \text{ m}$ and $\Delta H_{23} = 0.1163 \text{ m}$ of fluid. The complementary results table is as follows:

Designation	Symbol	Value	Unit
Left branch cross-section area	A1	0.003881508	m ²
Right branch cross-section area	A2	0.003881508	m ²
Common channel cross-section area	A3	0.003881508	m ²
Flow rate ratio 'Left branch / Common channel'	Q1/Q3	0.1666667	
Flow rate ratio 'Right branch / Common channel'	Q2/Q3	0.8333333	
Left branch Reynolds number	Re1	18050.2	
Right branch Reynolds number	Re2	90251	
Common channel Reynolds number	Re3	108301.2	
Left branch pressure loss coefficient (based on U3)	K13	0.6614556	
Right branch pressure loss coefficient (based on U3)	K23	0.9547221	
Left branch hydraulic power loss	Wh1	0.7888463	W
Right branch hydraulic power loss	Wh2	5.692967	W

References:

[1] Internal Flow System, Second Edition, D.S. Miller (1990)

