

PNL00R - Friction submodel of pneumatic pipe (R)

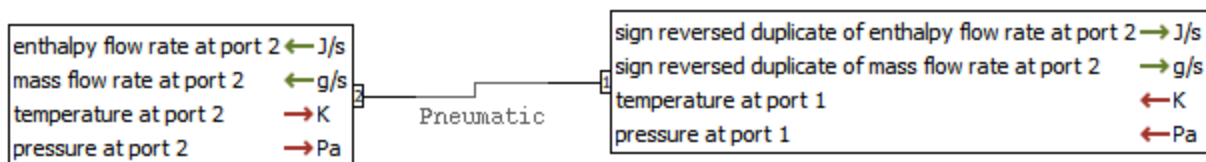
Description

PNL00R is a submodel of a pneumatic pipe or hose with only friction effects.

A pressure in Pa and a temperature in K are input at each ports and a mass flow rate in g/s and an enthalpy flow rate in J/s are computed to be output at both these ports.

Pipe friction is taken into account using a friction factor based on the Reynolds number and the relative roughness.

Icon with external variables



Usage

Use this submodel to simulate a pneumatic pipe with friction effects, when the Mach number is low, *i.e.* gas velocity < 0.3 * speed of sound.

The submodel [PNGD00](#) should be included in your circuit to define the characteristics of the gas.

Parameter settings

The *gas type index* parameter refers to a gas type defined by an icon put on the sketch.

The relative roughness Δ/D_{eq} is calculated as the ratio of the average height of asperities to the tube diameter:

$$\Delta/D_{eq} = \frac{\Delta}{D_{eq}}$$

where:

- Δ is the equivalent uniform roughness of the pipe,
- D_{eq} is the equivalent diameter of the pipe.

A sampling of absolute pipe roughness Δ for new clean pipes is proposed by Binder :

Pipe material	Absolute roughness Δ
drawn brass	1.5 μm
drawn copper	1.5 μm
commercial steel	45 μm
wrought iron	45 μm
asphalted cast iron	120 μm
galvanized iron	150 μm
cast iron	260 μm
wood stave	0.2 to 0.9 mm
concrete	0.3 to 3 mm
riveted steel	0.9 to 9 mm

Physics and equations

The flow rates are calculated using the utility [pn2pipefr](http://pn2pipe.fr).

Detailed submodel view

External variables

	Title	Variable name	Unit	Type	In/Out	Default value
Port 1						
1	duplicate of dh2	dh1	J/s	sign reversed duplicate [hidden]	output	-
2	duplicate of dm2	dm1	g/s	sign reversed duplicate [hidden]	output	-
3	temperature at port 1	t1	K	basic variable	input	-
4	pressure at port 1	p1	Pa	basic variable	input	-
Port 2						
1	enthalpy flow rate at port 2	dh2	J/s	basic variable	output	-
2	mass flow rate at port 2	dm2	g/s	basic variable	output	-
3	temperature at port 2	t2	K	basic variable	input	-
4	pressure at port 2	p2	Pa	basic variable	input	-

Internal variables

	Title	Variable name	Unit	Type	Default value
1	Reynolds number	re	null	basic variable	-

2	mass flow parameter (cm)	cm	$(\text{kg} \cdot \text{K} / \text{J})^{**}(1/2)$	basic variable	-
3	mean gas velocity	v	m/s	basic variable	-
4	friction factor	ff	null	basic variable	-

Real parameters

	Title	Variable name	Unit	Default value
1	diameter of pipe	diam	mm	10
2	pipe length	le	m	1
3	relative roughness	rr	null	1e-05

Integer parameters

	Title	Variable name	Default value
1	gas type index	gi	1

[Contents of the Pneumatic Lines library](#)