SIMULATION X®
Powered by ITI

Model Library

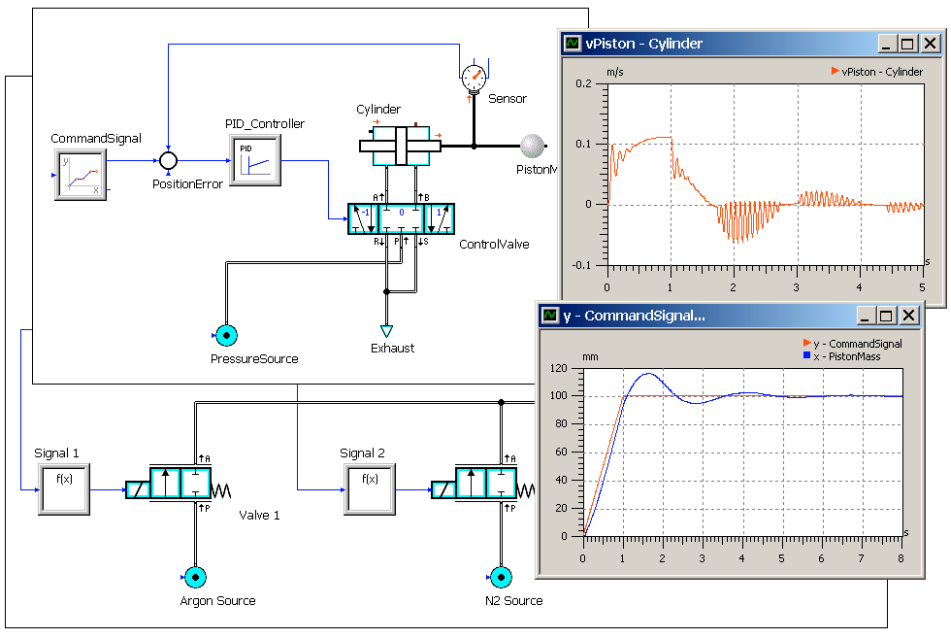
Pneumatics

The Pneumatics Library contains elements, which can be used for modeling of systems with internal gas flow, as for example:

- *Pneumatic drives and handling equipment,*
- *Hydro-pneumatic accumulators and shock absorbers, or*
- *Fuel cells and chemical process equipment.*

Models are created graphically-interactively according to the pneumatic circuit structure. The user does not need to set up differential equations or convert the circuit structure into a signal flow diagram. Several elements are available for interfacing the pneumatic circuit to other domains, such as mechanics (1D/3D), hydraulics, thermics, or signal processing and control. Moreover, the available standard elements can easily be enhanced, modified or grouped together by using the TypeDesigner.

The libraries Pneumatics I and Pneumatics II differ only with respect to the available types of gas. While the library Pneumatics I considers only pure gases, the library Pneumatics II also contains gas mixtures. This enables to simulate mixing processes as well.



- *Modeling and simulating of the dynamic behavior of pneumatic components and systems*
- *Tool for the holistic evaluation of the interactions between pneumatics, hydraulics, mechanics and control*
- *Structured standard pneumatic element types with basic elements, actuators, valves, pipes and accessories*
- *Fast adaptation and extension from element types to customized devices (structure, parameter inputs)*
- *Visualization and animation of the dynamic processes with pressure, mass flow etc. by using ITI-Vis3D*

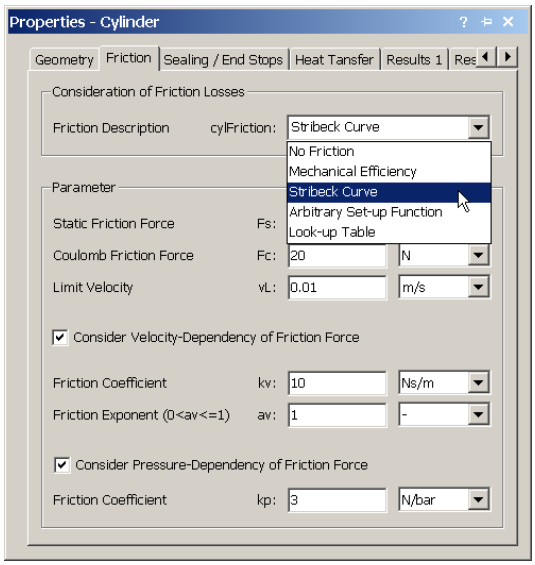
Library

The Pneumatics Library contains the following elements:

- Pneumatics
  - Basic Elements
    - Pressure Supply
    - Exhaust
    - Volume
    - Piston Area
  - Actuators
    - Double Rod Cylinder
    - Single Rod Cylinder
    - Rodless Cylinder
    - Cylinder with Spring
  - Valves
    - Constant Throttle Valve
    - Variable Throttle Valve
    - 2/2-Way Proportional Valve (direct acting, normally closed)
    - 2/2-Way Proportional Valve (direct acting, normally open)
    - 3/2 Directional Control Valve (direct acting, port A exhausted when de-energized)
    - 3/2 Directional Control Valve (direct acting, port A pressurized when de-energized)
    - 3/2 Distribution Valve (direct acting, P->B open, A closed when de-energized)
    - 3/2 Distribution Valve (direct acting, P->A open, B closed when de-energized)
    - 4/2 Directional Control Valve (direct acting, P->A, B->R open, P->B, A->R closed when de-energized)
    - 4/2 Directional Control Valve (direct acting, P->B, A->R open, P->A, B->R closed when de-energized)
    - 5/3 Directional Control Valve (direct acting, all ports normally closed)
    - Check Valve with Spring
    - Pressure Regulator
  - Lines
    - Pipe
    - Line (Distributed Model)
    - T-Junction 90°
    - Transition
    - Elbow
  - Accessories
    - Pressure Sensor
    - Temperature Sensor
    - Volume Flow Sensor
  - Compressors
    - Compressor
    - Simple Compressor

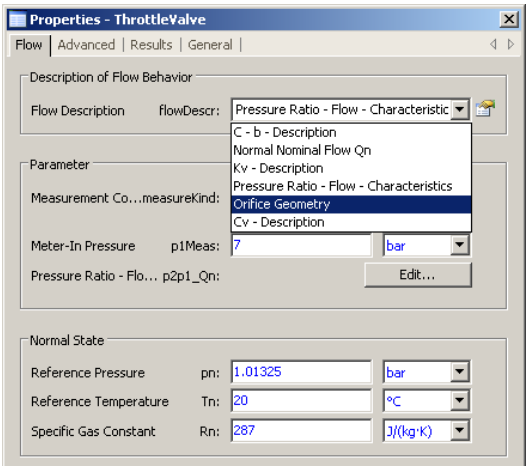
The element Double Rod Cylinder considers the following properties, besides the geometry of piston, piston rod and housing:

- *Cylinder friction (four alternative friction models)*
- *Elastic friction of sealing (optional)*
- *Mechanical end stops of piston housing (optional as spring-damper element or via impact number)*
- *Heat transfer between cylinder and environment (optional)*



The Pneumatic Valves allow the following approaches for describing the flow resistance of the valve:

- *C-b-Description (critical conductance C, critical pressure ration b)*
- *Normal nominal flow Qn*
- *Kv value*
- *Pressure ratio vs. normal flow data table*
- *Orifice geometry*
- *Cv Value*

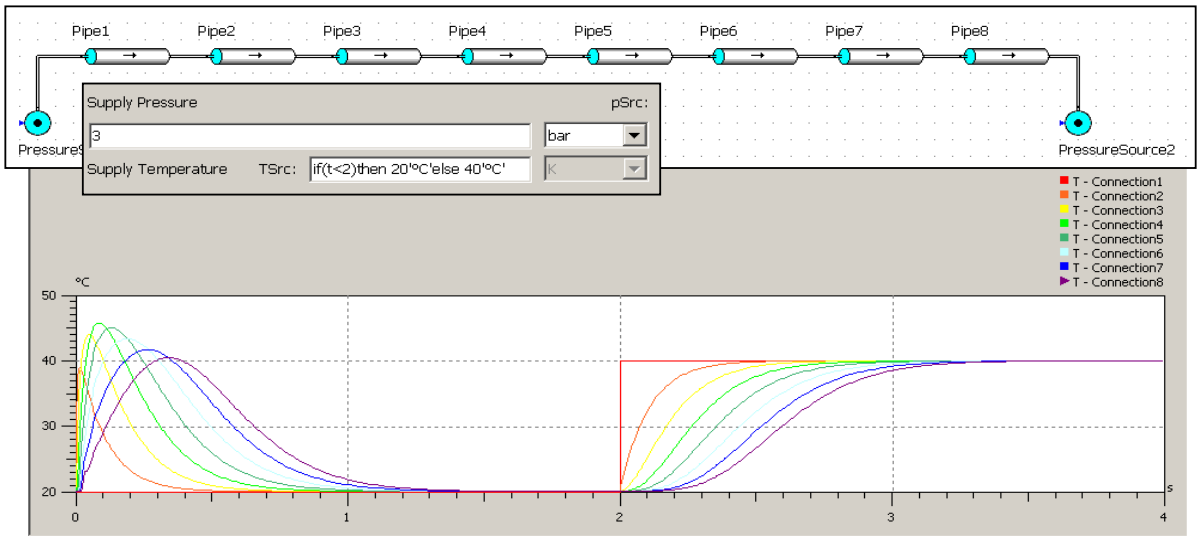


All resistance models include laminar as well as turbulent losses. Furthermore, all pneumatic resistances distinguish between sub-critical and super-critical flow behavior.

The elements of the sublibrary 'Actuators' considers the following features:

- *Laminar and turbulent friction losses,*
- *Rough surfaces,*
- *Inertia losses due to acceleration of the fluid mass, as well as*
- *Heat transfer between the gas flow and the pipe wall.*

Furthermore, special effects such as pressure oscillation, heat and mixture transport phenomena can be simulated by connecting several pipe elements in series.



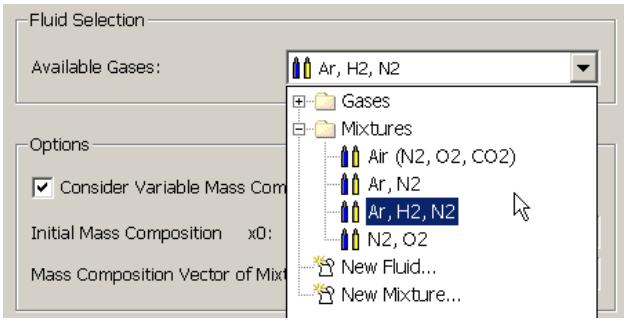
The behavior of pipe flows can be simulated even more accurate with the help of the element Line (Distributed Model). Here a comprehensive Finite-Volume-Method including the consideration of the unsteady friction as well as the interaction with the elastic pipe wall has been implemented.

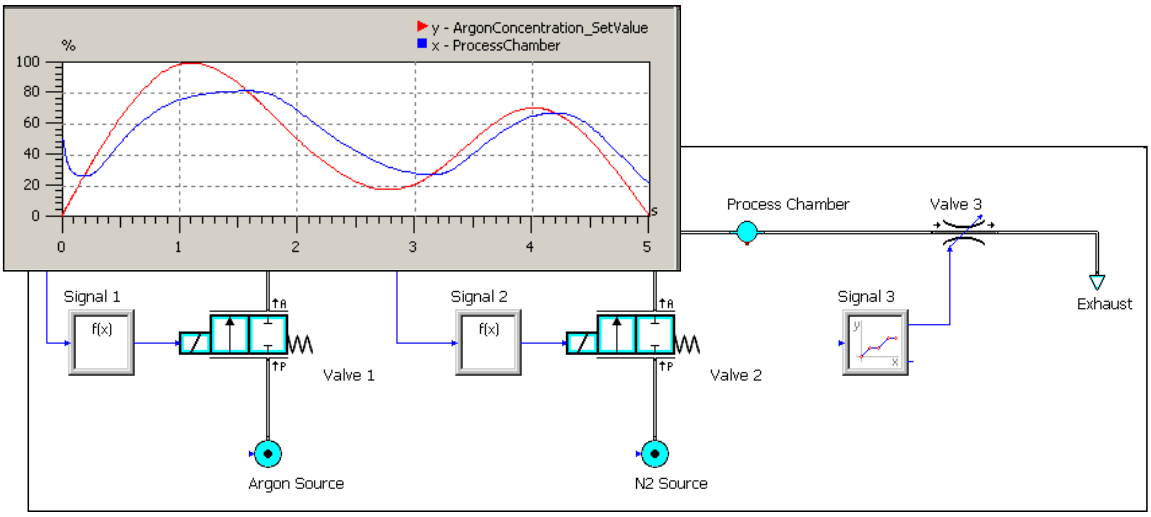
Fluid Library

The gas properties are calculated in the nodes (connections) of the network as a function of pressure, temperature and (for gas mixtures only) mixture concentration. The user can select the desired gas type in the parameter dialog of the connection. The selected gas is then valid for the entire circuit. This mechanism ensures, that different gas (or mixture) types can be used in the same model, but not in the same circuit. The list of pre-defined gases (and mixtures) can be modified or extended by the user.
For pure gases the calculation of state variables (pressure and temperature) is done by default for ideal gas. Optionally, the user can select different real-gas models (Bender model, Virial equation, Redlich-Kwong, Van-der-Waals).

Gas Mixtures

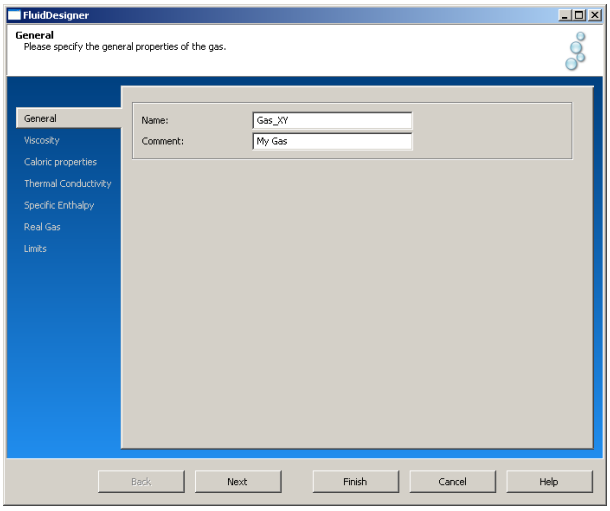
The library Pneumatics II offers not only pure gases, but also gas mixtures with variable concentration. The user can select the desired mixture type in the parameter dialog of the connection. The mixture composition is now calculated in each node (connection) as a function of the current mass flow balance. This allows to simulate mixing phenomena efficiently.





FluidDesigner

The ITI-FluidDesigner (optional) is comfortable tool for creation and editing of user defined fluids. Thus allows an efficient description of all for dynamic simulation relevant physical properties of fluid types (e.g. viscosity, density, and compressibility) subject to the state quantities pressure, temperature and gas fraction.



A comprehensive offer of alternative possibilities for the description of fluid properties (e.g. default or arbitrary setup function, curves) guarantees a high flexibility to the user. The validity of the fluid description can be determined by editing of limits for pressure and temperature. (See also FluidDesigner Hydraulics Library).