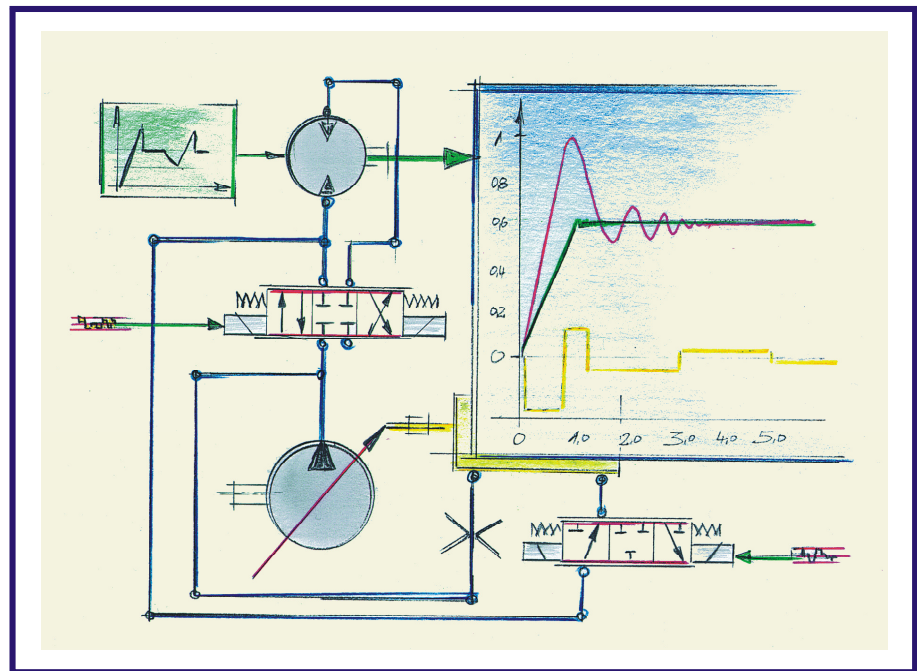


Component Manual

Thermo Hydraulics



DSH^{plus}

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In the course of further development of the software, parts of this manual can lose their validity.

Introduction

The component manual describes the components of the library. In accordance with the component categories in the library, the manual subdivides itself into several parts:

- Component library Hydraulics
- Component library Pneumatics
- Component library Control,
- Component library Mechanics
- Component library Thermal Hydraulics
- Component library Modules
- Component library Miscellaneous

The **HYDRAULICS** part contains all hydraulic components of the library. This includes pumps and motors, flow valves, pressure valves, check valves, and directional valves as well as accumulators and pipes.

The **PNEUMATICS** part of the library includes many components for pneumatic systems. The components range from cylinders and resistors to directional valves and sensors.

In the manual part **MECHANICS** the mechanical components are described. These are the masses and the spring damper components as well as other mechanical components.

The component library of *DSHplus* includes analog and digital components for control tasks that are explained in the chapter **CONTROL**.

The **THERMAL HYDRAULICS** part contains thermal hydraulic components of the library. This includes pumps and motors and directional valves as well as accumulators and pipes.

The component manual should help to select the right component for a model and to parameterize it. Furthermore, there is information about the kind of modeling of the components, e. g. whether they were modeled in accordance with the physical qualities of the real components or whether only their dynamic characteristics were taken.

The **MODULES** contains the components for the *DSHplus*-STC and for the sub model prepare. The part **MISCELLANEOUS** contains other components to which the nodes in particular belong.

All components are described according to the same scheme. The following page shows an example component with which the scheme is explained.

ComponentName

Symbol of the component

Symbol

Sketch

Drawing of the component

Connectors and Variables

Name	Type	Unit	Description
<i>Hydraulic connector</i>	Hydr	Unit	<i>short description</i>
<i>Hydraulic volume less connector</i>	Hvol	Unit	<i>short description</i>
<i>Thermal hydraulic connector</i>	THydr	Unit	<i>short description</i>
<i>Pneumatic connector</i>	Pneu	Unit	<i>short description</i>
<i>Signal input</i>	In		<i>short description</i>
<i>Signal output</i>	Out		<i>short description</i>
<i>Mechanical connector</i>	Mech		<i>short description</i>
<i>Internal variable</i>	V		<i>short description</i>

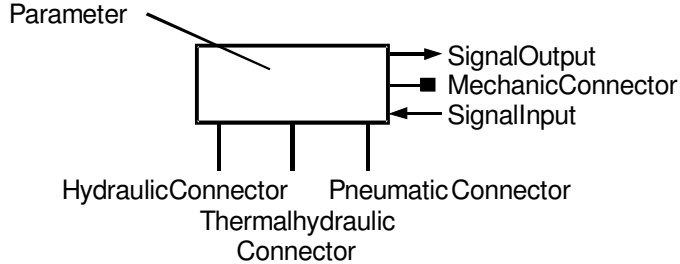
Parameters

Name	Value	Unit	Description
<i>Parameter name</i>	<i>Value</i>	<i>Unit</i>	<i>short description</i>

Notes

Remarks about function and application

Comments to the example component:

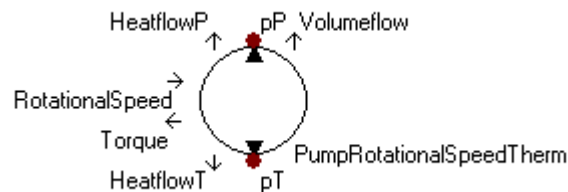
	The component symbol is the symbol with which a component appears in the library and in the model.														
	The component with its parameters and its connectors is represented in the component drawing according to the following figure:  The arrows at the component specify whether the connector is an input, an output or a mechanical connection. The direction of state variables is defined by a coordinate system.														
	In the table Connectors and Variables , all connectors and variables of a component are listed.														
	The connectors and variables of a component can be subdivided into different types. They are characterized in the column Type in accordance with: <table> <tbody> <tr> <td>Hydr:</td><td>hydraulic connector</td></tr> <tr> <td>Pneu:</td><td>pneumatic connector</td></tr> <tr> <td>Thydr:</td><td>thermal hydraulic connector</td></tr> <tr> <td>In:</td><td>input of a signal</td></tr> <tr> <td>Out:</td><td>output of a signal</td></tr> <tr> <td>Mech:</td><td>mechanical connector</td></tr> <tr> <td>V:</td><td>internal variable (state variable)</td></tr> </tbody> </table>	Hydr:	hydraulic connector	Pneu:	pneumatic connector	Thydr:	thermal hydraulic connector	In:	input of a signal	Out:	output of a signal	Mech:	mechanical connector	V:	internal variable (state variable)
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Thydr:	thermal hydraulic connector														
In:	input of a signal														
Out:	output of a signal														
Mech:	mechanical connector														
V:	internal variable (state variable)														
	Units (column Unit) were assigned to the variables. In so far as the customer does not change the Units, the graphic or numeric edition of the variables occurs with these Units. The units for the values of the other connectors are listed only for better understanding.														
	In the parameter list, all parameters are listed with its Values and Units with which a component is described.														
	The Notes give further remarks to the function and the application of the component.														
	The following spelling is used: COMPONENTNAME <i>Parameters, Connectors and Variables</i>														

Contents

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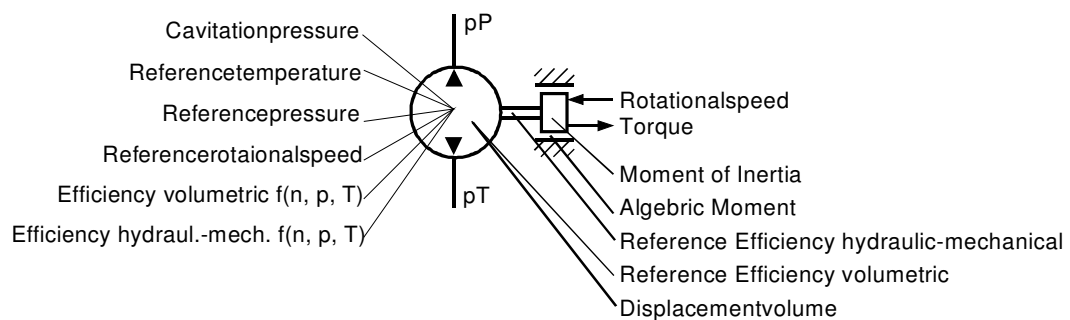
Thermal Hydraulics

PumpRotationalSpeedTherm



Symbol

Sketch



Connections and variables

Name	Type	Unit	Description
pP	THydr	bar	Operating pressure
pT	THydr	bar	Tank pressure
RotationalSpeed	In	1/min	number of revolutions
Torque	Out	Nm	Torque for the given rotational speed
Volumeflow	Out	l/min	volume flow
HeatflowP	Out	W	Heat flow in the connection pP
HeatflowT	Out	W	Heat flow in the connection pT
RotationalSpeedPT1	V	-	Internal auxiliary variable for the determination of the moment

Parameter

Name	Value	Unit	Description
DisplacementVolume	32	cm ³	delivery at one rotation of the pump without leakage
TorqueofInertia	0.05	kgm ²	Moment of inertia of the rotary pump parts

Name	Value	Unit	Description
DerivateActiontime	1	ms	Internal auxiliary variable for the determination of the moment
AlgebraicSignMoment	-1	-	Algebraic sign for the output moment
ReferenceTemperature	313.15	K	Reference temperature at reference point
ReferencePressure	100	bar	Pressure at reference points
ReferenceRotationalSpeed	1000	1/min	Rotational speed at reference point
ReferenceEthaVol	100	%	Volumetric efficiency at the reference point
EthaVolRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference
EthaVolPressureDependency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaVolTemperatureDependency	0	%/K	Upward gradient of the change of the efficiency in the point of reference
ReferenceEthaHM	100	%	Hydraulic-mechanical efficiency at the point of reference
EthaHMRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference
EthaHMPressureDependency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaHMTemperatureDependency	0	%/K	Upward gradient of the change of the efficiency in the point of reference
CavitationPressure	-0.5	bar	Cavitation starts

Notes

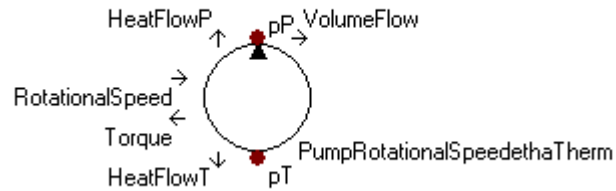
The Component PumprotationalspeedTherm is a model of a pump, whose number of revolutions is given and the necessary torque is computed. Inertias and friction moments are considered.

The torque is differentiated by the principle of conservation of angular momentum. therefore the DerivateActiontime is needed.

The parameter AlgebraicSignMoment adapts the sign of the torque if it is for further connections with other components.

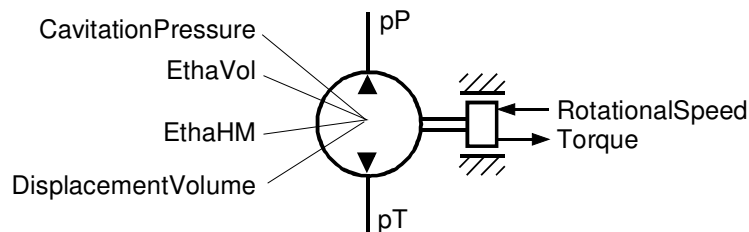
Depending from the direction of rotation, both p_P and p_T is the high pressure side of the pump. In principle the flow rate refers (independently of the promotion direction) to the connection p_P .

PumpRotationalSpeedEthaTherm



Symbol

Sketch



Connections and variables

Name	Type	Unit	Description
pP	THydr	bar	Operating pressure
pT	THydr	bar	Tank pressure
RotationalSpeed	In	1/min	Number of revolutions
Torque	Out	Nm	Torque for the given rotational speed
Volumeflow	Out	l/min	Promote volume flow
HeatflowP	Out	W	Heat flow in the connection pP
HeatflowT	Out	W	Heat flow in the connection pT

Parameter

Name	Value	Unit	Description
DisplacementVolume	32	cm ³	delivery at one rotation of the pump without leakage
EthaHM	100	%-	Hydraulic-mechanical efficiency
EthaVol	100	% ³	Volumetric efficiency
CavitationPressure	-0.5	bar	Cavitation starts
EthaHMCharacteristics	-		Characteristic diagram hydraulic-mechanical efficiency

Name	Value	Unit	Description
EthaVolCharacteristics	-	-	Characteristic diagram volumetric efficiency

Notes

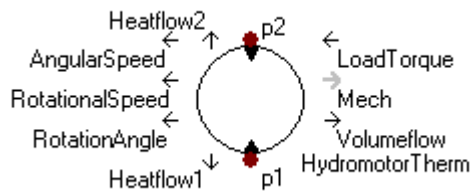
The component PUMPROTATIONALSPEEDETHATHERM is the model of a pump, which computes the flow rate either with the help of both two-dimensional characteristic diagrams the *EthaHMCharacteristics* and *EthaVolCharacteristics* or over the parameters *EthaHM* and *EthaVol*.

Characteristic diagrams define the flow rate as a function of the number of revolutions n and the difference of pressure $p_P - p_T$.

If characteristic diagrams are defined, then the static defaults for the efficiencies are not effective.

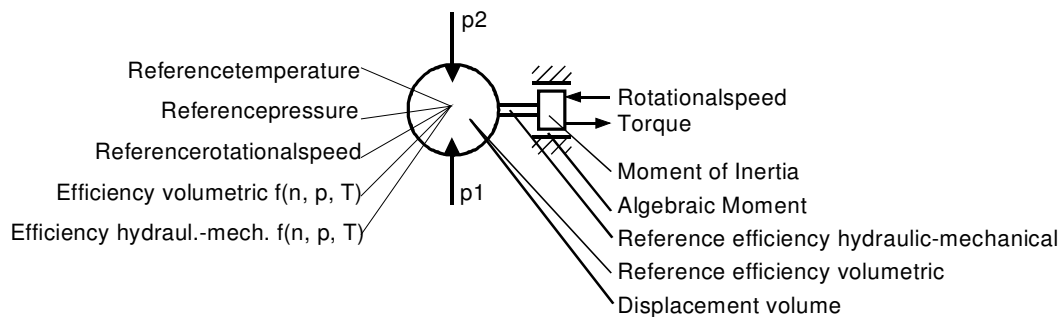
The flow rate always refers to the connection p_P .

HydroMotorTherm



Symbol

Sketch



Connections and variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure in connection p1
p2	THydr	bar	Pressure in connection p2
Volumeflow	Out	l/min	Volume flow in connection p1
Mech	Mech	-	Mechanical connection
MechM	In	Nm	Torque
Mechphi	Out	deg	rotation angle
Mechomega	Out	deg/s	angular speed
LoadTorque	In	Nm	Torque at the motor
AngularSpeed	Out	deg/s	Angular speed of the engine
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
RotationAngle	Out	deg	Angle of rotation of the engine
RotationalSpeed	Out	1/min	Engine speed

Parameter

Name	Value	Unit	Description
DisplacementVolume	50	cm ³	delivery at one rotation of the pump without leakage

Name	Value	Unit	Description
TorqueofInertia	0.05	kgm ²	Moment of inertia of the rotary engine parts
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point
ReferenceRotationalSpeed	1000	1/min	Number of revolutions in the reference operating point
ReferenceEthaVol	100	%	volumetric efficiency in the reference operating point
EthaVolRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference
EthaVolPressureDependency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaVolTemperatureDependency	0	%/K	Upward gradient of the change of the efficiency in the point of reference
ReferenceEthaHM	100	%	hydraulic-mechanical efficiency in the reference operating point
EthaHMRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference
EthaHMPressureDependency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaHMTemperatureDependency	0	%/K	Upward gradient of the change of the efficiency in the point of reference

Notes

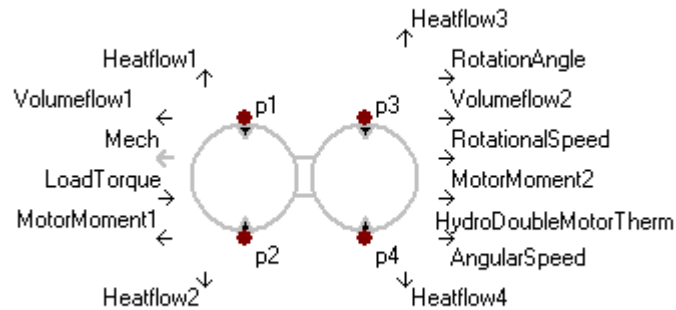
The component HYDROMOTORTHERM is the model of a constant hydraulic motor.

Depending from the direction of rotation both P1 and p2 can designate the high pressure side of the engine.

If $p_1 > p_2$, a positive number of revolutions arises. If the load torque > 0 , a positive acceleration arises. In principle the flow rate refers (independently of the direction of rotation) to the port p1.

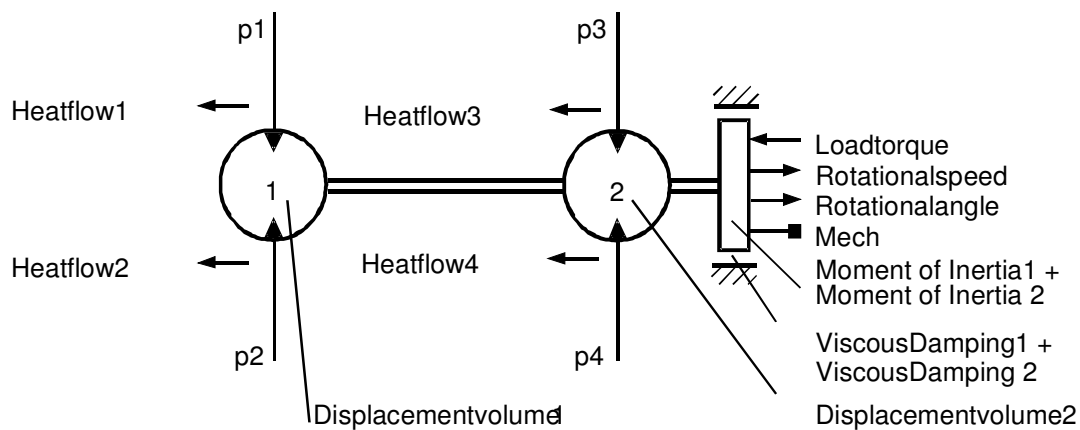
In the mechanical connection *Mech* of the component are summarized as the angle of rotation of the engine (Mechphi), the angular speed (mechanical omega) and the *loadtorque* (MechM).

HydroDoubleMotorTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure in connection p1
p2	THydr	bar	Pressure in connection p2
p3	THydr	bar	Pressure in connection p3
p4	THydr	bar	Pressure in connection p4
Mech	Mech	-	Mechanical connection
MechM	In	Nm	Torque
Mechphi	Out	deg	rotation angle
Mechomega	Out	deg/s	angular speed
LoadTorque	In	Nm	Torque at the motor
Volumeflow1	Out	l/min	Volume flow in Connection p1
Volumeflow2	Out	l/min	Volume flow in Connection p3

Name	Type	Unit	Description
MotorMoment1	Out	Nm	torque delivered by the engine1
MotorMoment2	Out	Nm	torque delivered by the engine1
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
Heatflow3	Out	W	Heat flow in connection p3
Heatflow4	Out	W	Heat flow in connection p4
RotationalSpeed	Out	1/min	Engine rotational speed
RotationAngle	Out	deg	Engine rotation angle

Parameter

Name	Value	Unit	Description
DisplacementVolume1	50	cm ³	delivery at one rotation of the engine 1 without leakage
DisplacementVolume2	50	cm ³	delivery at one rotation of the engine 2 without leakage
TorqueofInertia1	1	kgm ²	Moment of inertia of the rotary engine parts (engine 1)
TorqueofInertia2	1	kgm ²	Moment of inertia of the rotary engine parts (engine 2)
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point
ReferenceRotationalSpeed	1000	1/min	Number of revolutions in the reference operating point
ReferenceEthaVol	100	%	volumetric efficiency in the reference operating point
EthaVolRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference
EthaVolPressureDependency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaVolTemperatureDependency	0	%/K	Upward gradient of the change of the efficiency in the point of reference
ReferenceEthaHM	100	%	hydraulic-mechanical efficiency in the reference operating point
EthaHMRotationalSpeedDependency	0	%/(1/min)	Upward gradient of the change of the efficiency in the point of reference

Name	Value	Unit	Description
EthaHMPressureDepend- ency	0	%/(bar)	Upward gradient of the change of the efficiency in the point of reference
EthaHMTemperature De- pendency	0	%/K	Upward gradient of the change of the efficiency in the point of reference

Notes

The component HYDRODOUBLEMOTORTHERM is the model of two constant hydraulic engines, which are installed on a wave. In addition to component a Hydrotransformer can be realized.

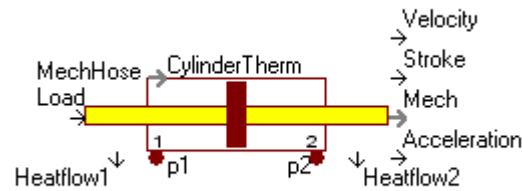
$p_1 > p_2$ or $p_3 > p_4$ arises a positive number of revolutions. The load torque > 0 arises a positive acceleration. Depending upon direction of rotation both p_1 and p_3 and p_2 and p_4 can designate the high pressure side of the engine.

In principle the Volumeflow1 refers (independently of the direction of rotation) to the connection P1, the Volumeflow2 to p3.

Over the component connections MotorMoment1 and MotorMoment2 can be measured from the torques delivered effectively by the engines.

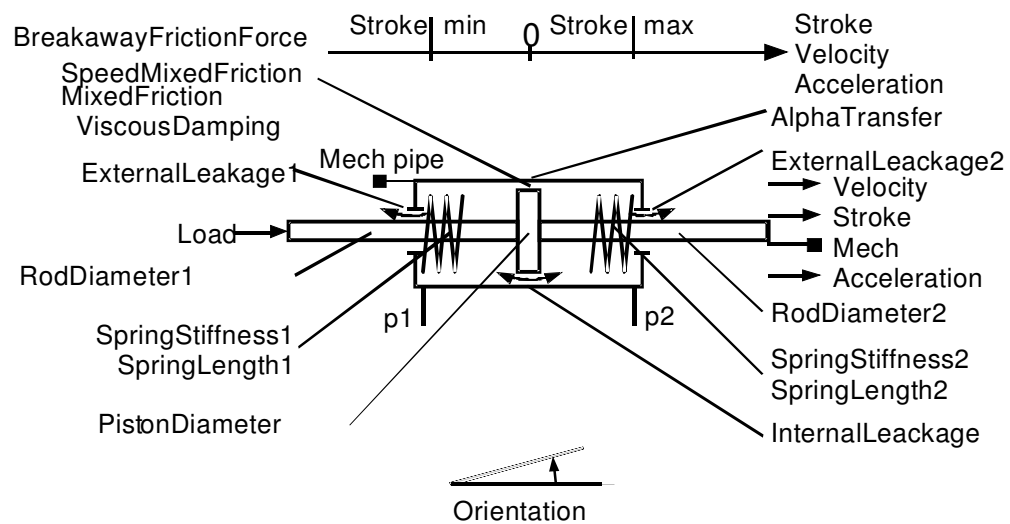
In the mechanical connection *Mech*, the component HYDROMOTORTHERM are summarized as the angle of rotation of the engine (Mechphi), the angular speed (mechanical omega) and the load torque (MechM).

CylinderTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure in connection 1
p2	THydr	bar	Pressure in connection 2
Load	In	N	Power adjoining at the piston
Mech	Mech	-	Mechanical connection
MechF	In	N	Power adjoining at the piston
Mechx	Out	mm	Piston Stroke
Mechv	Out	m/s	Piston Velocity

Name	Type	Unit	Description
MechPipe	Mech	-	Mechanical connection
MechF	Out	N	internal strength at cylinder
Mechx	In	mm	pipe
Mechv	In	m/s	Stroke of cylinder pipe
			velocity of cylinder pipe
Acceleration	Out	m/s ²	Acceleration of piston
Velocity	Out	m/s	Velocity of piston
Stroke	Out	mm	Stroke of piston
Heatflow1	Out	W	Heat flow in connection1
Heatflow2	Out	W	Heat flow in connection 2

Parameter

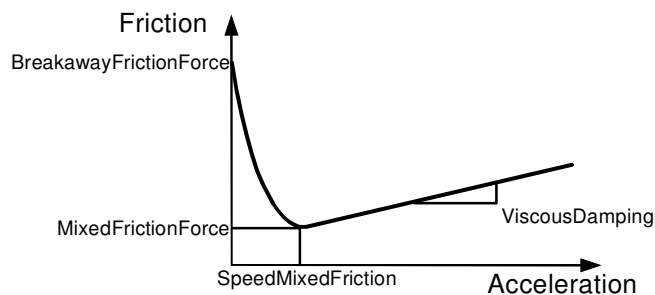
Name	Value	Unit	Description
PistonDiameter	100	mm	Diameter of piston
RodDiameter1	50	mm	Diameter of rod 1
RodDiameter2	0	mm	Diameter of Rod 2
Strokemax	100	mm	Maximum piston stroke in positive direction
Strokemin	-100	mm	Maximum piston stroke in negative direction
Mass	10	kg	Mass of pistons and piston rod
BreakawayFrictionForce	100	N	Characteristic value for the Stribeck curve
MixedFrictionForce	10	N	Characteristic value for the Stribeck curve
SpeedMixedFriction	0.1	m/s	Characteristic value for the Stribeck curve
ViscousDamping	10	Ns/m	Characteristic value for the Stribeck curve
Orientation	0	deg	Angle of the cylinder axle to horizontals
ExternalLeakage1	0	l/min/bar	From the cylinder at the piston rod 1 withdrawing hydraulic fluid
ExternalLeakage2	0	l/min/bar	From the cylinder at the piston rod 2 withdrawing hydraulic fluid
InternalLeakage	0.001	l/min/bar	Internal Leakage
SpringLength1	0	mm	Active length of the spring 1
SpringStiffness1	0	N/mm	Stiffness of the spring1
SpringLength 2	0	mm	Active length of the spring 2
SpringStiffness 2	0	N/mm	Stiffness of the spring 2

Name	Value	Unit	Description
AlphaTransfer	75	W/(m ² *K)	linear heat transmission coefficient of the cylinder surface

Notes

The component CYLINDER THERM is the model of an equal course or a differential cylinder, which is headed for over two thermal hydraulic connections and with that the friction between pistons and cylinder wall is considered. If a differential cylinder is needed, a rod diameter (Roddiameter1 or Rodiameter2) with zero must be only parameterized.

In this case the external leakage (ExternalLeakage1 or ExternalLeakage2) for this cylinder is set automatically to zero. As component symbol can be selected between an equal course and a differential cylinder.



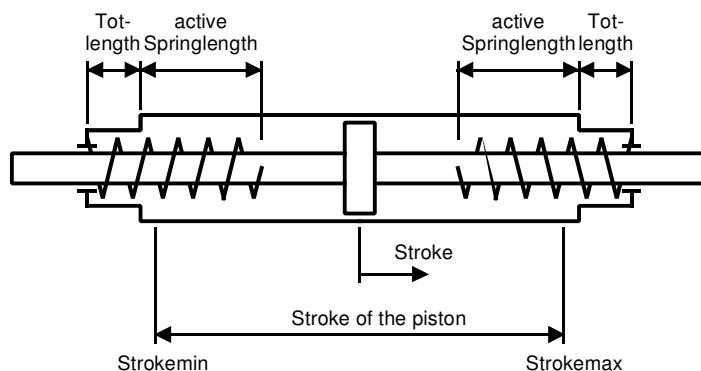
The speed-dependent friction between pistons and cylinder wall is modeled in accordance with the Stribeck curve. The characteristic values *Breakawayfrictionforce*, *Mixedfrictionforce*, *Speedmixedfriction* and *Viscousdamping* describe the points of the friction curve represented in the picture and its upward gradient within the range of the pure friction of a liquid. The frictional force is pressure independent.

In the mechanical connection *Mech* the component are summarized as the stroke of the cylinder (*Mechx*), the velocity (*Mechv*) and the Load (*MechF*).

With the mechanical connection mechanical pipe can be supported the cylinder against environment. Since the cylinder pipe is mass less in the model, an external mass must be attached, which can be supported again e.g. with a spring against environment.

With the *Orientation*, the movement plane can be sloped in any angle to the horizontal. The resulting force due to gravity is considered automatically.

Under the parameter *Springlength* becomes the active spring length, understood thus overall length of the spring less the dead length. The following picture shows the principle sketch of a cylinder, in which also the dead lengths of the springs are drawn in:



The overall length of the spring is measured in the relaxed condition. It is possible therefore that the active spring length (*Springlength1* or *Springlength*) is larger than the stroke

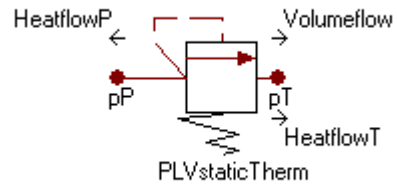
(Strokemax - Strokemin) of the piston. In this case the springs would be constantly strained. Otherwise the springs are not constant in the interference.

The computation of convection at the component surface is described by the component surface A_B and the pertinent material-dependent heat transmission coefficient α_B .

$$\dot{Q}_B = \alpha_B \cdot A_B \cdot \Delta T$$

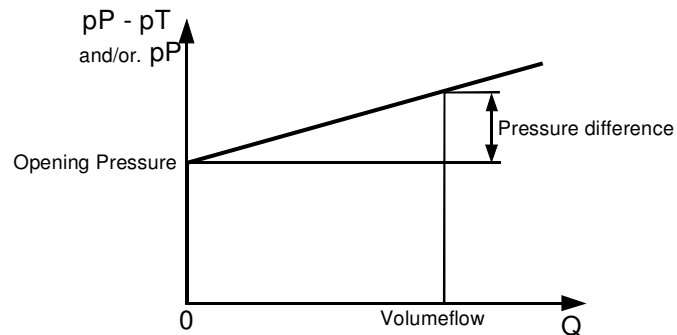
The computation of convection takes place for each cylinder chamber in dependence of the current piston position. The surface adds itself from the stroke-dependent lateral surface and the front surface of the cylinder chamber. The front surfaces are regarded as piston area. Convection by the piston rod is not considered.

PLVstaticTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
pP	THydr	bar	Input pressure
pT	THydr	bar	Tank pressure
Volumeflow	Out	l/min	Flowing off flow rate (Q)
HeatflowP	Out	W	Heat flow in connection P
HeatflowT	Out	W	Heat flow in connection T

Parameter

Name	Value	Unit	Description
OpeningPressure	200	bar	pressure required to open the valve
PressureDifference	5	bar	see above
Volumeflow	30	l/min	flow through the valve at a <i>PressureDifference</i>
ReferenceTemperature	313.15	K	Temperature in the reference point
ReferencePressure	100	bar	Pressure in the reference point
Balanced	1	-	See remarks

Notes

The component PLVSTATIC THERM is the model of a direct-controlled pressure relief valve. With reaching the point of opening the valve opens, so that hydraulic fluid can flow off to the tank. The flowing off flow rate takes linear with rising difference of pressure ($p_P - p_T$ and/or p_P) too.

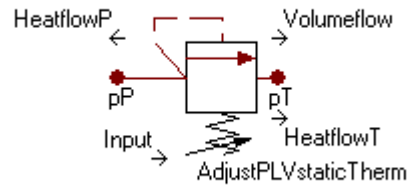
A relief valve (relieves = 1) opens, as soon as supply pressure p_P becomes larger than opening pressure (opening condition: $p_P > \text{opening pressure}$). If a not relieved valve is used (relieved = 0), also the pressure at the connection affects itself p_T the point of opening out (opening condition: $p_P - > \text{opening pressure } p_T$).

The component PLVSTATIC THERM no model of a pressure relief valve is in accordance with its physical structure, but copies only the characteristic of a pressure relief valve. That is, that with this model dynamic effects (e.g. forces of inertia), which due to the physical structure of a pressure relief valve arise are not considered.

A static pressure relief valve is available also as component, with which the point of opening is adjustable during the simulation (ADJUST PLVSTATIC THERM).

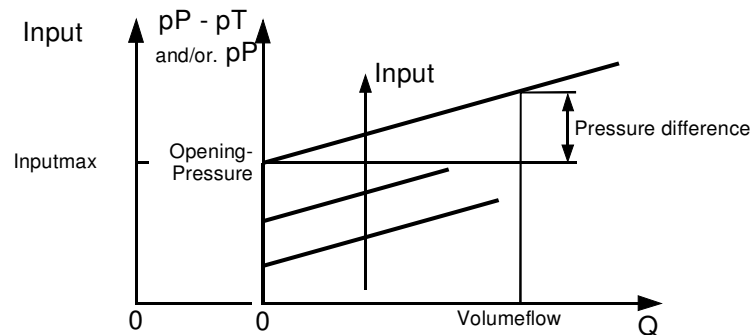
The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the screen factor temperature-dependent.

AdjustPLVstaticTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
pP	THydr	bar	Input pressure
pT	THydr	bar	Tank pressure
Input	In	-	Input signal
Volumeflow	Out	l/min	Flowing off flow rate (Q)
HeatflowP	Out	W	Heat flow in connection P
HeatflowT	Out	W	Heat flow in connection T

Parameter

Name	Value	Unit	Description
Volumeflow	30	l/min	Flow rate by the valve with lying close <i>pressuredifference</i>
PressureDifference	5	bar	See above
ReferenceTemperature	313.15	K	Temperature in reference operating point
ReferencePressure	100	bar	Pressure in reference operating point

Name	Value	Unit	Description
OpeningPressure	200	bar	pressure required to open the valve
InputMax	1	-	Maximum input signal
Balanced	1	-	See remarks

Notes

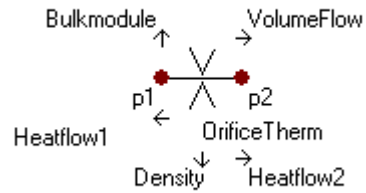
The component ADJUSTPLVSTATIC THERM is the model of a direct-controlled pressure relief valve. The point of opening can be adjusted with the *Input* signal. The valve opens and the fluid flows to the reservoir, when the point of opening is reached. The flowing off flow rate takes linear with rising difference of pressure ($p_P - p_T$ and/or p_P) too.

A relief valve (Balanced = 1) opens, as soon as the supply pressure p_P becomes larger than the opening pressure (opening condition: $p_P > \text{opening pressure}$). If a not relieved valve is used (Balanced = 0), also the pressure at the connection affects itself p_T the point of opening out (opening condition: $p_P - > \text{opening pressure } p_T$).

The component ADJUSTPLVSTATIC THERM no model of a pressure relief valve is in accordance with its physical structure, but copies only the characteristic of a pressure relief valve. That is, that with this model dynamic effects (e.g. forces of inertia), which due to the physical structure of a pressure relief valve arise are not considered.

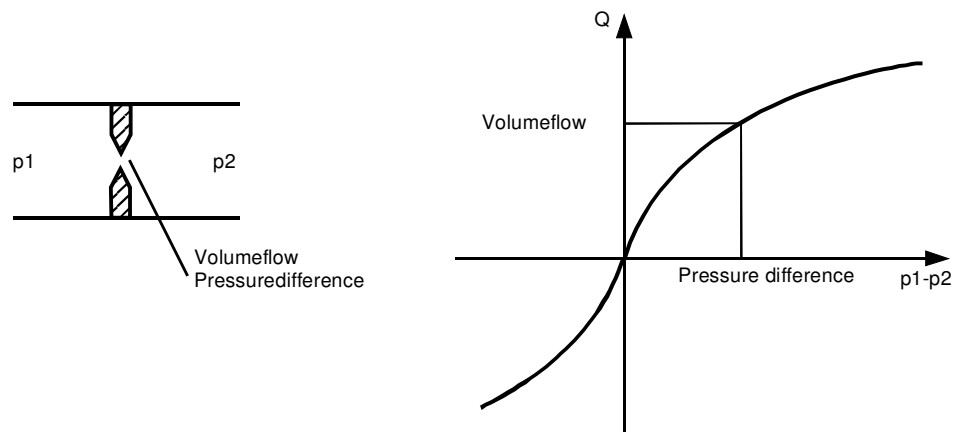
The data to the point of reference for the temperature and the pressure are needed, to correct the conductance during the simulation temperature dependant.

OrificeTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure on side 1
p2	THydr	bar	Pressure on side 2
VolumeFlow	Out	l/min	Volume flow through the orifice plate (Q)
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
Bulkmodule	Out	bar	Pressure and temperature dependent bulk module of the fluid
Density	Out	kg/m3	Pressure and temperature dependent density of the fluid

Parameter

Name	Value	Unit	Description
VolumeFlow	30	l/min	Flow rate by the orifice plate with difference of pressure

Name	Value	Unit	Description
PressureDifference	5	bar	see above
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point

Notes

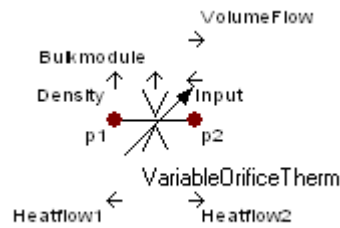
The component ORIFICE THERM is the model of a flow resistance with to a large extent radial dependence on the difference of pressure resting against the construction unit p_1 - p_2 and the flow rate. It is parameterized over the hydraulic characteristic values flow rate and difference of pressure.

The ORIFICE THERM is suitable for the modeling of a orifice plate opening, if the relationship of its length is relatively small l to its diameter D . (approx. $l/d < 1,5$).

The flow rate depends on the viscosity of the hydraulic fluid.

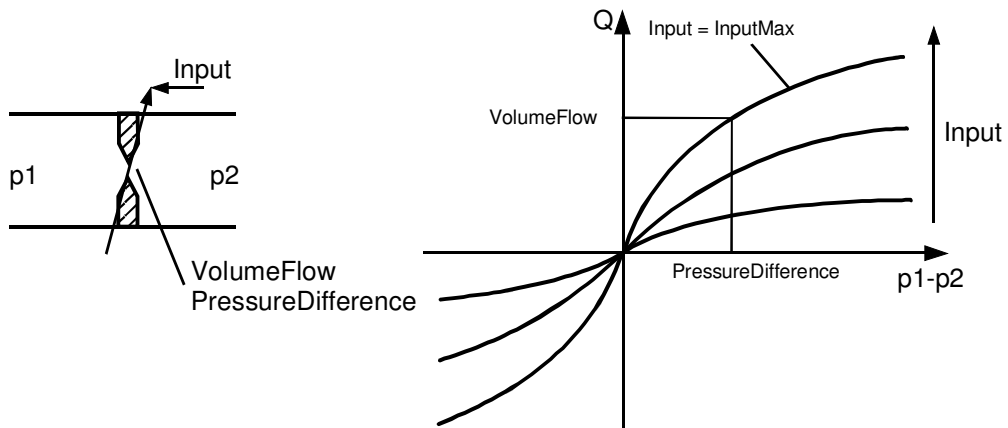
The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the screen factor temperature-dependent.

VariableOrificeTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure on side 1
p2	THydr	bar	Pressure on side 2
Input	In	-	input signal to adjust the orifice
VolumeFlow	Out	l/min	Volume flow through the orifice plate (Q)
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
Bulkmodule	Out	bar	Pressure and temperature dependent bulk module of the fluid
Density	Out	kg/m ³	Pressure and temperature dependent density of the fluid

Parameter

Name	Value	Unit	Description
VolumeFlow	30	l/min	Flow rate by the orifice plate with difference of pressure

Name	Value	Unit	Description
PressureDifference	5	bar	see above
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point

Notes

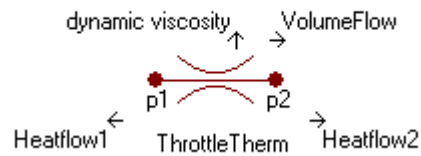
The component VariableORIFICE_{THERM} is the model of a flow resistance with to a large extent radial dependence on the difference of pressure resting against the construction unit p_1-p_2 and the flow rate. It is parameterized over the hydraulic characteristic values flow rate and difference of pressure. The relation between the *VolumeFlow* and the *Pressure-Difference* p_1-p_2 is adjustable via the *input* signal.

The VariableORIFICE_{THERM} is suitable for the modeling of a orifice plate opening, if the relationship of its length is relatively small l to its diameter D . (approx. $l/D < 1,5$).

The flow rate depends on the viscosity of the hydraulic fluid.

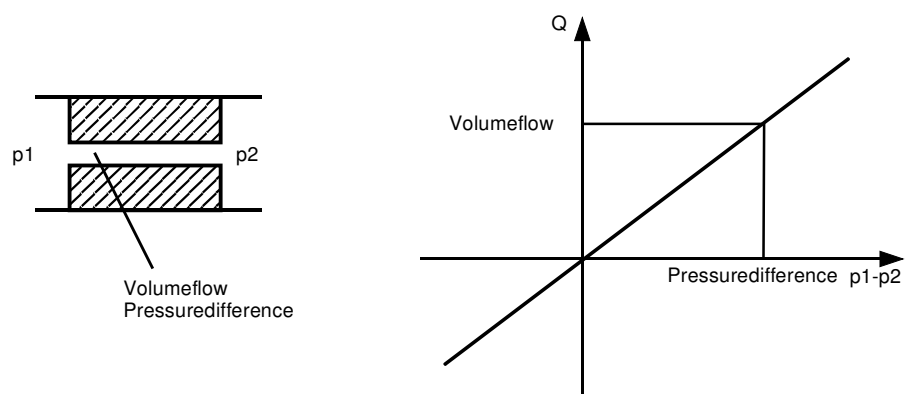
The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the screen factor temperature-dependent.

ThrottleTherm



Symbol

Sketch



Connection and variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure on side 1
p2	THydr	bar	Pressure on side 2
Volumeflow	Out	l/min	Volume flow through the orifice plate (Q)
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
dynamic viscosity	Out	Ns/m ²	Pressure and temperature-dependent viscosity

Parameter

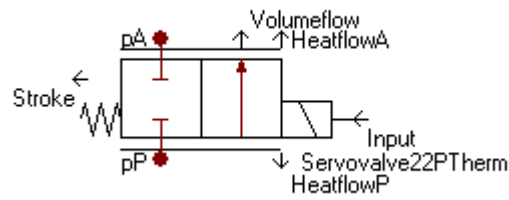
Name	Value	Unit	Description
VolumeFlow	30	l/min	Flow rate by the orifice plate with difference of pressure
PressureDifference	5	bar	see above
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point

Notes

The component `THROTTLE_THERM` is the model of a flow resistance with to a large extent linear dependence of the difference of pressure resting against the construction unit is $p_1 - p_2$ of the flow rate. It is parameterized over the hydraulic characteristic values flow rate with difference of pressure. The dynamic viscosity can be spent over the connection of the same name.

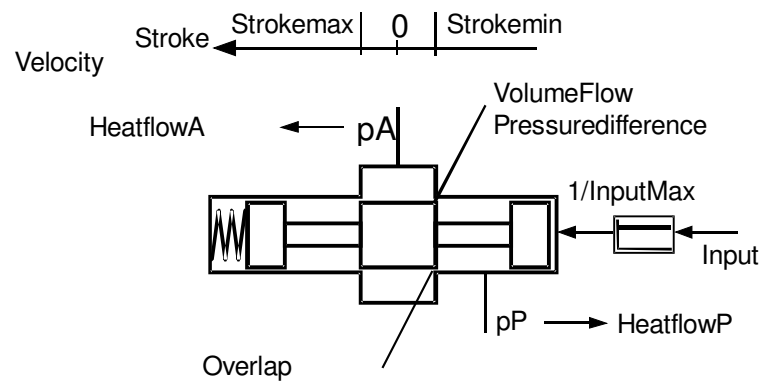
The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the throttle conductance temperature dependent.

Servovalve22PTTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
pP	THydr	bar	Supply pressure
pA	THydr	bar	Operating pressure
Input	In	-	Input signal for spool valves
Stroke	Out	mm	Stroke of the spool valve
VolumeFlow	Out	l/min	Volume flow
HeatflowA	Out	W	Heat flow in connection A
HeatflowP	Out	W	Heat flow in connection P

Parameter

Name	Value	Unit	Description
VolumeFlow	30	l/min	Flow rate with maximum cross-section of the opening and lying close difference of pressure
PressureDifference	35	bar	see above
ReferenceTemperature	313.15	K	Temperature in the reference operating point

Name	Value	Unit	Description
ReferencePressure	100	bar	Pressure in the reference operating point
Strokemax	1	mm	Maximum slide stroke in positive direction
Strokemin	0	mm	Maximum slide stroke in negative direction
Overlap	0	%	Relative cover of the control edge
InputMax	1	-	Standardizing size for input signal

Notes

The component `SERVOVALVE22PTHERM` is the model of a 2/2-Wege-Proportionalvalves, whose slide stroke behaves proportionally to the input signal. The flow characteristic of the valve is indicated over the parameters flow rate and difference of pressure and the cover.

For the overlap of the control edge:

Overlap < 0: Valve in resting position opened

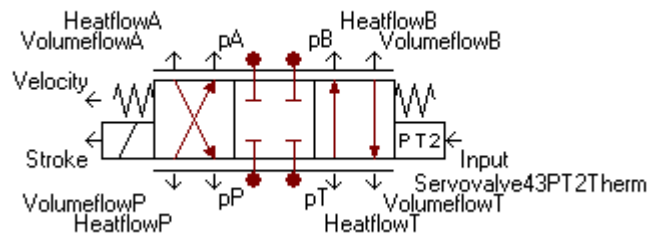
Overlap = 0: Valve in resting position straight closed

Overlap > 0: Valve in resting position closed

The component `SWITCHINGVALVE22PTHERM` is no model of the physical structure of a valve, but copies only its characteristic characteristics. Therefore physical characteristic values (e.g. slide gate valve, mass or spring rigidity) are not parameterized.

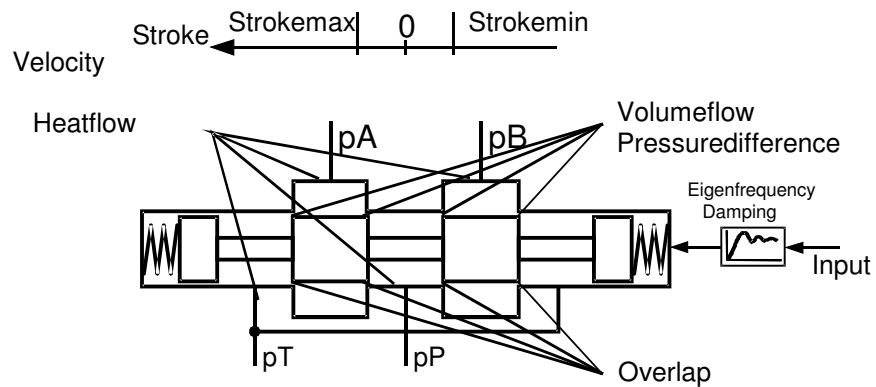
The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the screen factor temperature-dependent.

Servovalve43PT2Therm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
pP	THydr	bar	Supply pressure
pT	THydr	bar	Tank pressure
pA	THydr	bar	Operating pressure A
pB	THydr	bar	Operating pressure B
Input	In	-	Input signal for spool valves
Volumeflow P	Out	l/min	Volume flow in connection P
Volumeflow T	Out	l/min	Volume flow in connection T
Volumeflow A	Out	l/min	Volume flow in connection A
Volumeflow B	Out	l/min	Volume flow in connection B
Heatflow P	Out	W	Heat flow in connection P
Heatflow T	Out	W	Heat flow in connection T
Heatflow A	Out	W	Heat flow in connection A
Heatflow B	Out	W	Heat flow in connection B
Stroke	Out	mm	Valve stroke
velocity	Out	m/s	Valve velocity

Parameter

Name	Value	Unit	Description
Volumeflow	30	l/min	Flow rate with maximum cross-section of the opening and lying close difference of pressure
PressureDifference	35	bar	See above
ReferenceTemperature	313.15	K	Temperature in reference operating point
ReferencePressure	100	bar	Pressure in reference operating point
Overlap	0	%	Relative cover of the control edge
EigenFrequency	50	Hz	Parameter for heading for characteristic
Damping	0.7	-	Parameter for heading for characteristic
Velocitymax	1E99	m/s	Maximum valve speed in positive direction
Velocitymin	-1E99	m/s	Maximum valve speed in negative direction
InputMax	1	-	Standardizing size for input signal
Strokemax	1	mm	Maximum valve stroke in positive direction
Strokemin	-1	mm	Maximum valve stroke in negative direction

Notes

The component `SERVOVALVE43PT2THERM` is the model of a 4/3-Wege-Proportionalvalves headed for over a signal, whereby the way of the valve slide behaves proportionally to the input signal with a delay of second order. The flow characteristic of the valve becomes over the parameters *Volumeflow* and *Pressuredifference* and the overlap indicated.

There is overlap at all control edges and it apply:

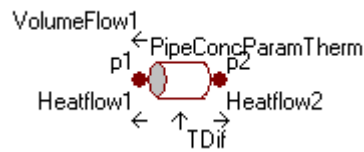
- Overlap* < 0: Control edges in resting position opened
- Overlap* = 0: Control edges in resting position straight closed
- Overlap* > 0: Control edges in resting position closed

The component `SERVOVALVE43PT2THERM` is no model of the physical structure of a valve, but copies only its characteristic characteristics. Physical characteristic values (e.g. valve mass or spring rigidity) are not parameterized, since the way of the valve slide is dependent only on the signal at the entrance, of the natural frequency and the absorption.

Over the parameters speed max and speed min the speed limiting of the valve slide movement can be stopped, which is caused by the flow delimitation of the control.

The data to the point of reference for the temperature and the pressure are needed, in order to correct during the simulation the screen factor temperature-dependent.

PipeConcParamTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure at the tube end 1
p2	THydr	bar	Pressure at the tube end 2
VolumeFlow1	Out	l/min	Flow rate through the pipe
Heatflow1	Out	W	Heat flow in connection1
Heatflow2	Out	W	Heat flow in connection 2
VolumeFlow	V	l/min	Pipe volume flow
TDif	In	K	Temperature difference to the environment temperature

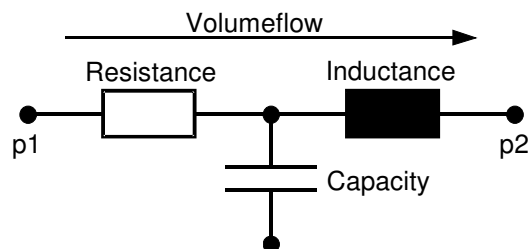
Parameter

Name	Value	Unit	Description
PipeLength	1	m	Length of pipe
PipeOutsideDiameter	36	mm	Outside diameter of the pipe
PipeInnerDiameter	32	mm	Inner diameter of the pipe
AlphaTransfer	75	W/(m ² *K)	linear heat transmission coefficient of the pipe wall
LambdaInsulation	0	W/(m*K)	Constant of the tube insulation (heat guidance coefficient)
AdditionalThrottleFlowrate	30	l/min	Flow rate by the throttle with difference of pressure
AdditionalThrottlePressureDifference	0	m	see above
AltitudeDifference	0	m	Difference in height between the tube ends
AccelerationDuetoGravity	9.81	m/s ²	Acceleration due to gravity

Name	Value	Unit	Description
ReferenceTemperature	313.15	K	Temperature at reference operating point
ReferencePressure	10	bar	Pressure at reference operating point

Notes

The component PIPECONCPARAMTHERM is the model of a piping, which illustrates a pipe as hydraulic inductance and hydraulic resistance. The hydraulic capacity of the pipe is considered by the THERMAL HYDRAULIC KNOTS at the tube ends, on which the liquid volume of the pipe is divided automatically (see picture).



The friction in the pipe is flow rate-dependently computed.

With the help of the parameter *AltitudeDifference* a difference in height between the pipe connectors can be considered. The parameter *AltitudeDifference* has to be > 0 if p2 is in a higher position.

For the modelling of a pipe several components PIPECONCPARAMTHERM must be lined up. The number of n of the tubing construction units should be selected in such a way that the length of the tubing sections is smaller than 1/10 of the wavelength of the highest still interesting frequency f.

Has if the pipe, which is to be illustrated, the length L, then to have

$$n > 10 \cdot \frac{L \cdot f}{c_0}$$

component PIPECONCPARAMTHERM are lined up. The wave velocity c0 computes itself after

$$c_0 = \sqrt{\frac{E'_{öl}}{\rho}}$$

with the spare bulk modulus $E'_{öl}$ and density ρ .

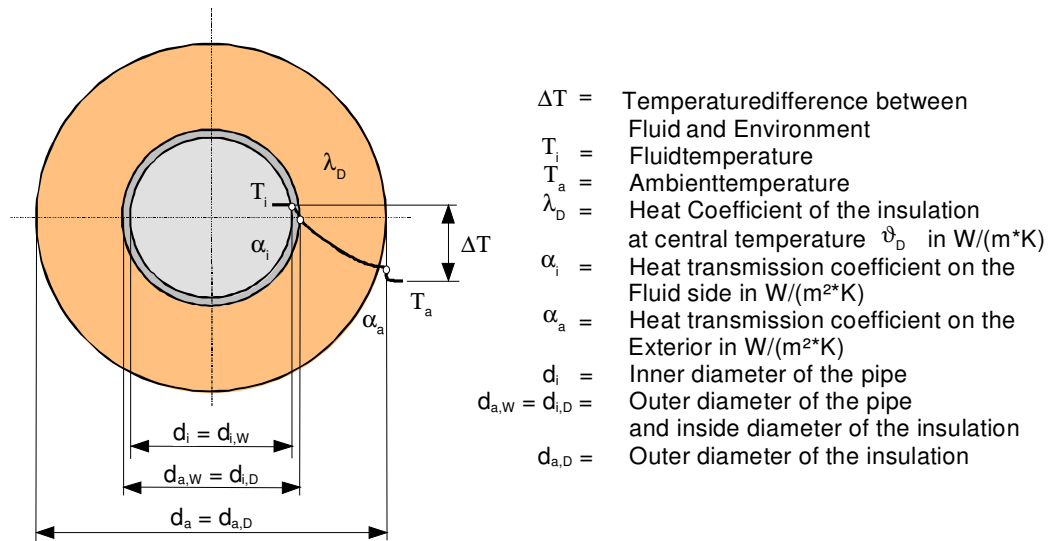
The number of construction units in line decides on the accuracy of the model.

The computation of convection at the pipe wall can be computed as follows:

$$\dot{Q}_L = \dot{q}_L \cdot L$$

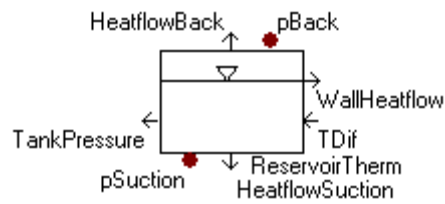
The heat transfer of the pipe wall results after the following connection:

$$\dot{q}_L = \frac{\pi \cdot \Delta T}{\frac{1}{2 \cdot \lambda_D} \cdot \ln \frac{d_{a,D}}{d_{i,D}} + \frac{1}{\alpha_a \cdot d_a}}$$



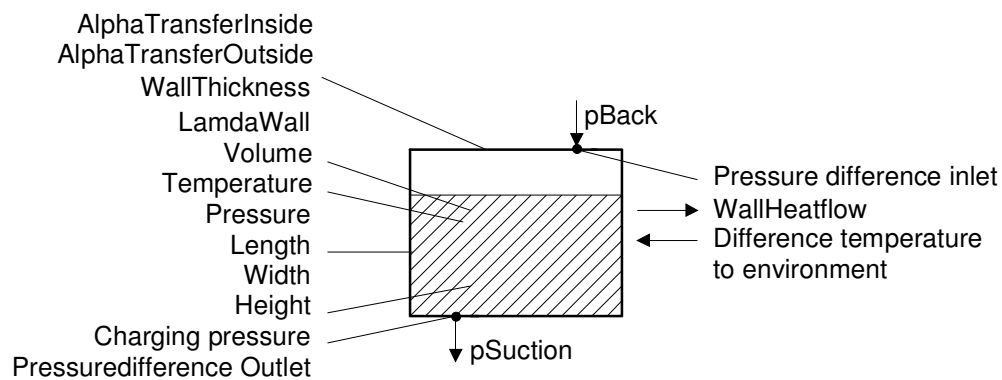
Radiant heat in axial direction by the pipe wall is not considered.

ReservoirTherm



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
pSuction	THydr	bar	Pressure at tank outlet
pBack	THydr	bar	Pressure at tank inlet
HeatflowBack	Out	W	Heat flow in the connection heat flow back
HeatflowSuction	Out	W	Heat flow in the connection heat flow suction
TankPressure	Out	bar	Pressure in the tank
WallHeatflow	Out	W	Heat flow in the connection wall heat flow
TDif	In	K	Temperature difference to the environment temperature
Volume	V	l	Tank level
Temperature	V	K	Fluid temperature at the beginning of the calculation

Parameter

Name	Value	Unit	Description
Height	0.3	m	Height of tank
Width	0.5	m	Width of tank
Depth	0.3	m	Depth of tank
AlphaTransferInside	75.0	W/(m ² *K)	Heat transmission coefficient of the tank wall
AlphaTransferOutside	75.0	W/(m ² *K)	Heat transmission coefficient of the tank wall
WallThickness	5.0	mm	tank wall thickness
LambdaWall	0.18	W/(m*K)	Thermal conductivity of the tank wall
ChargingPressure	0	bar	static charging pressure of the tank
Volumeflow	100	l/min	Flow through the tank
PressureDifferenceEin	0.005	bar	<i>Pressure difference</i> in tank inlet
PressureDifferenceAus	0.01	bar	<i>Pressure difference</i> in tank outlet
ReferenceTemperature	313.15	K	Temperature in the reference operating point
ReferencePressure	100	bar	Pressure in the reference operating point

Notes

The component RESERVOIRTHERM is the model of a cuboidal tank, whose volume computes itself from the parameters *Depth*, *Width* and *height*.

The liquid level of the tank is given over the variable *Volume*. The fluid technical system is regarded thereby as "filled" and "vented". Shifting volumes possibly existing cylinder must be considered with the parameterization.

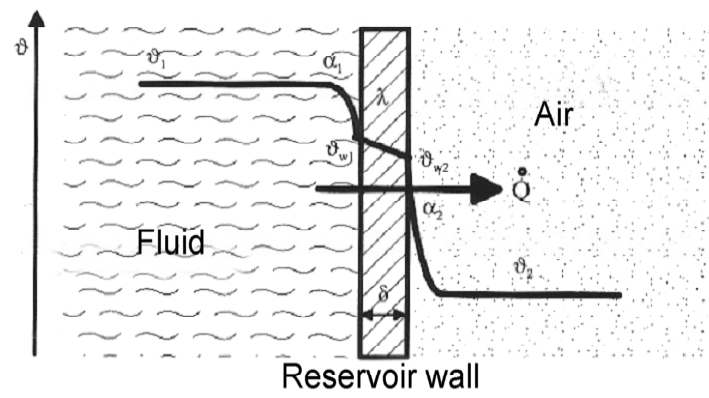
Should be taken more fluid out of the tank than it contains according to parameterization during the simulation, the simulation is stopped with a warning.

The computation of the wall convection at the surface is described by the component surface *A* and the pertinent material-dependent heat transmission coefficient α_{Inside} , $\alpha_{Outside}$, the wallthickness δ and the thermal conductivity λ of the tank wall.

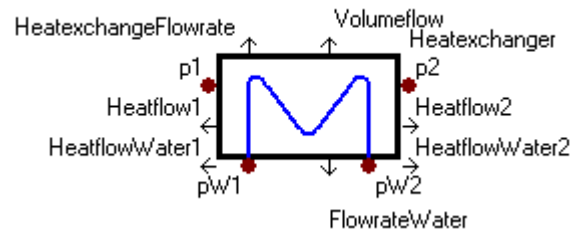
$$\dot{Q}_B = \frac{1}{\frac{1}{\alpha_{inside}} + \frac{\delta}{\lambda} + \frac{1}{\alpha_{outside}}} \cdot A \cdot \Delta T$$

The component surface of the RESERVOIRTHERM is computed as summation of all six surfaces.

The data to the point of reference for the temperature and the pressure are needed, in order to correct the screen factor temperature-dependent during the simulation.

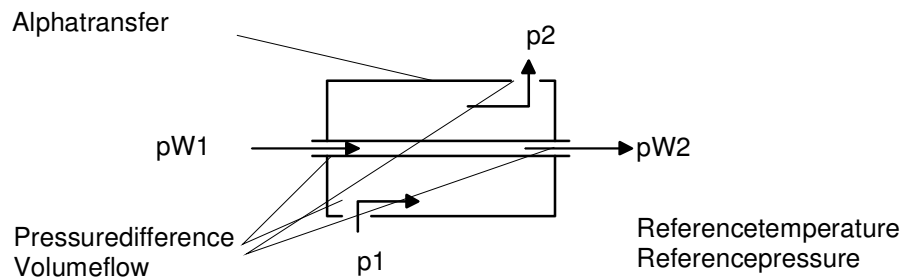


Heatexchanger



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	THydr	bar	Pressure in input p1
p2	THydr	bar	Pressure in input p2
pW1	THydr	bar	Pressure in input pW1
pW2	THydr	bar	Pressure in input pW2
Volumeflow	Out	l/min	Fluid flow rate through the component
FlowrateWater	Out	l/min	Water flow rate through the component
Heatflow1	Out	W	Heat flow in connection p1
Heatflow2	Out	W	Heat flow in connection p2
HeatflowWater1	Out	W	Heat flow in connection pW1
HeatflowWater2	Out	W	Heat flow in connection pW2
HeatexchangeFlowrate	Out	W	Difference of the heat flow of fluid and water

Parameter

Name	Value	Unit	Description
VolumeFlowFluid1	30	l/min	<i>VolumeFlow</i> through the radiator with lying close <i>PressureDifferenceFluid1</i>
PressureDifferenceFluid1	5	bar	s. o.
ReferenceTemperature-Fluid1	313.15	K	Temperature of the fluid 1 in the reference operating point
ReferencePressureFluid1	100	bar	Pressure of the fluid 1 in the reference operating point
VolumeFlowFluid2	30	l/min	<i>FlowrateWater</i> through the radiator with lying close <i>PressureDifferenceFluid2</i>
PressureDifferenceFluid2	5	bar	s. o.
ReferenceTemperature-Fluid2	313.15	K	Temperature of the fluid 2 in the reference operating point
ReferencePressureFluid2	100	bar	Pressure of the fluid 2 in the reference operating point
Length	0.5	m	Length of the radiator
Width	0.5	m	Width of the radiator
Depth	0.5	m	Depth of the radiator
AlphaTransfer	75.0	W/(m ² *K)	Heat transmission coefficient of the radiator wall

Notes

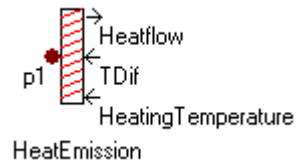
The component HEATEXCHANGER is the model of a cube shaped heat exchanger, which is flowed through by two media, between which a heat exchange takes place.

The computation of convection at the component surface is described by the component surface A_B and the pertinent material-dependent heat transmission coefficient α_B .

$$\dot{Q}_B = \alpha_B \cdot A_B \cdot \Delta T$$

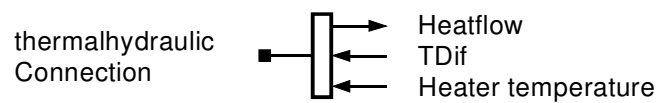
The component surface of the heat exchanger is computed as summation of all six surfaces.

HeatEmission



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	In	bar	Pressure in connection p1
HeatingTemperature	In	K	Temperature default
Heatflow	Out	W	Heat flow in connection p1
TDif	In	K	Temperature difference to the ambient temperature

Parameter

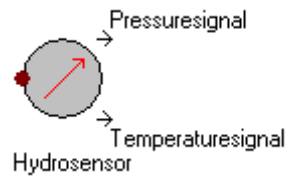
Name	Value	Unit	Description
AlphaTransfer	75	W/(m ² *K)	Heat transmission coefficient
SurfaceArea	100	cm ²	Radiating surface
HeatingDelayTime	20	s	Delay, with which a fluid heating up at the wall surface becomes apparent
TDifSurfaceToEnvironment	0	k	Temperature difference of the surface for environment

Notes

The component HEATEXCHANGER serves an external temperature default for the default and for measuring the heat flow in a thermal hydraulic knot. If it is attached to a thermal hydraulic knot, signal inputs (heater temperature and heat flow) can a temperature be fed over its and a heat flow be spent.

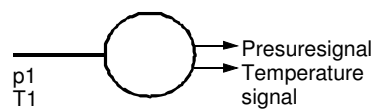
In addition the temperature difference of the component to the environment temperature can be set intern by the parameter *TdifSurfaceEnvironment* and/or external by the connection *TDif*.

Hydrosensor



Symbol

Sketch



Connection and Variables

Name	Type	Unit	Description
p1	In	bar	Pressure in connection p1
Pressuresignal	Out	bar	Pressure pick-up
Temperaturesignal	Out	K	Temperature pick-up

Parameter

Name	Value	Unit	Description
-	-	-	-

Notes

The component HYDROSENSOR serves for the pick-up of thermal hydraulic measured variables. If it is attached to a thermal hydraulic knot, signal outputs (pressure signal and temperature signal) can be indicated the pressure and the temperature in the knot over its.