



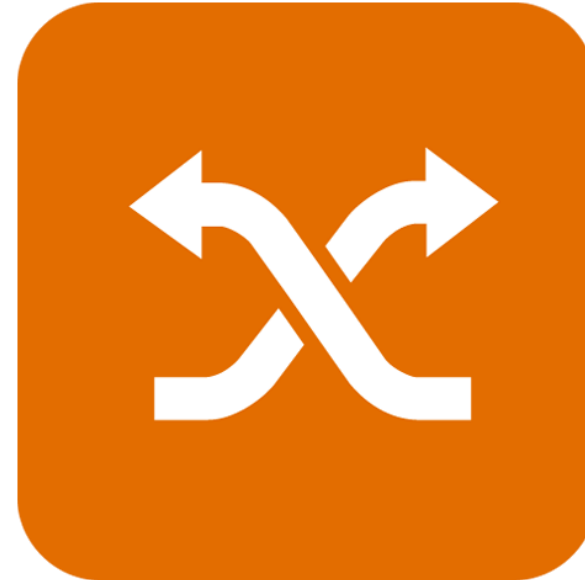
HEAT EXCHANGER LIBRARY

Overview



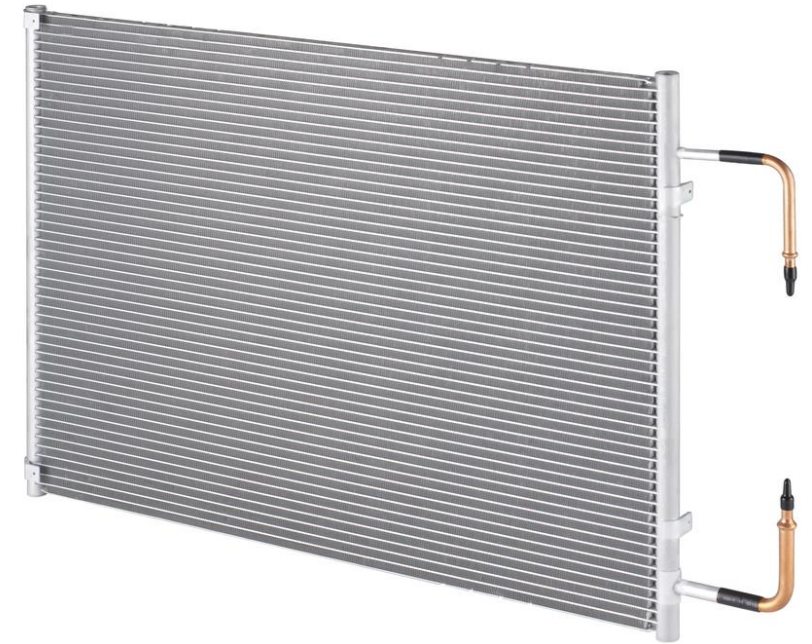
AGENDA

- About Heat Exchanger Library
- Key Features
- Key Capabilities
- Key Applications
- Library Contents
- Modelon Compatibility
- Latest Release



ABOUT HEAT EXCHANGER LIBRARY

- Modelica library by Modelon
- Geometric, segmented heat exchanger models
- Several flat tube and louvered fin designs
- Plate heat exchangers with plain plates, Chevron or louvered fins
- Inhomogeneous flow and temperature distribution
- Heat exchanger stacking
- Coupling to CFD data
- Prescribed air flow, or driven by pressure gradient – also for inhomogeneous distributions

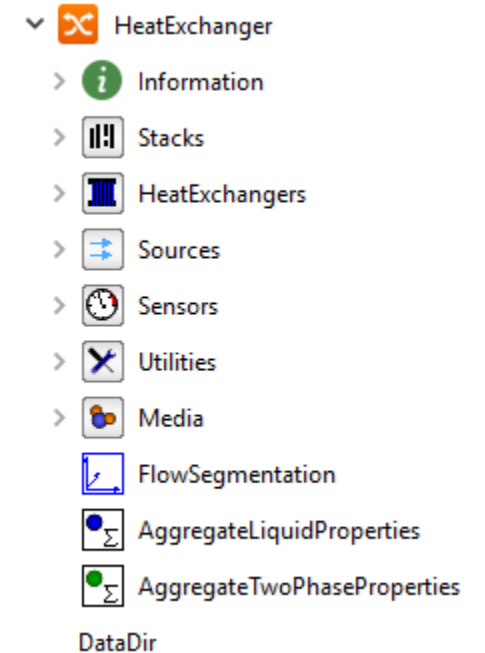




KEY BENEFITS

KEY BENEFITS

- Geometric models of flat tube and plate heat exchangers
- Geometric friction and heat transfer correlations
- Air side interface allows heat exchanger stacking
- Automatic area fraction calculations on flow segment level
- 2D – discretized and lumped flow source and sensor components
- Plug-and-play compatible with other Modelon libraries for thermal management
- Common heat exchanger interface across all Modelon thermal libraries

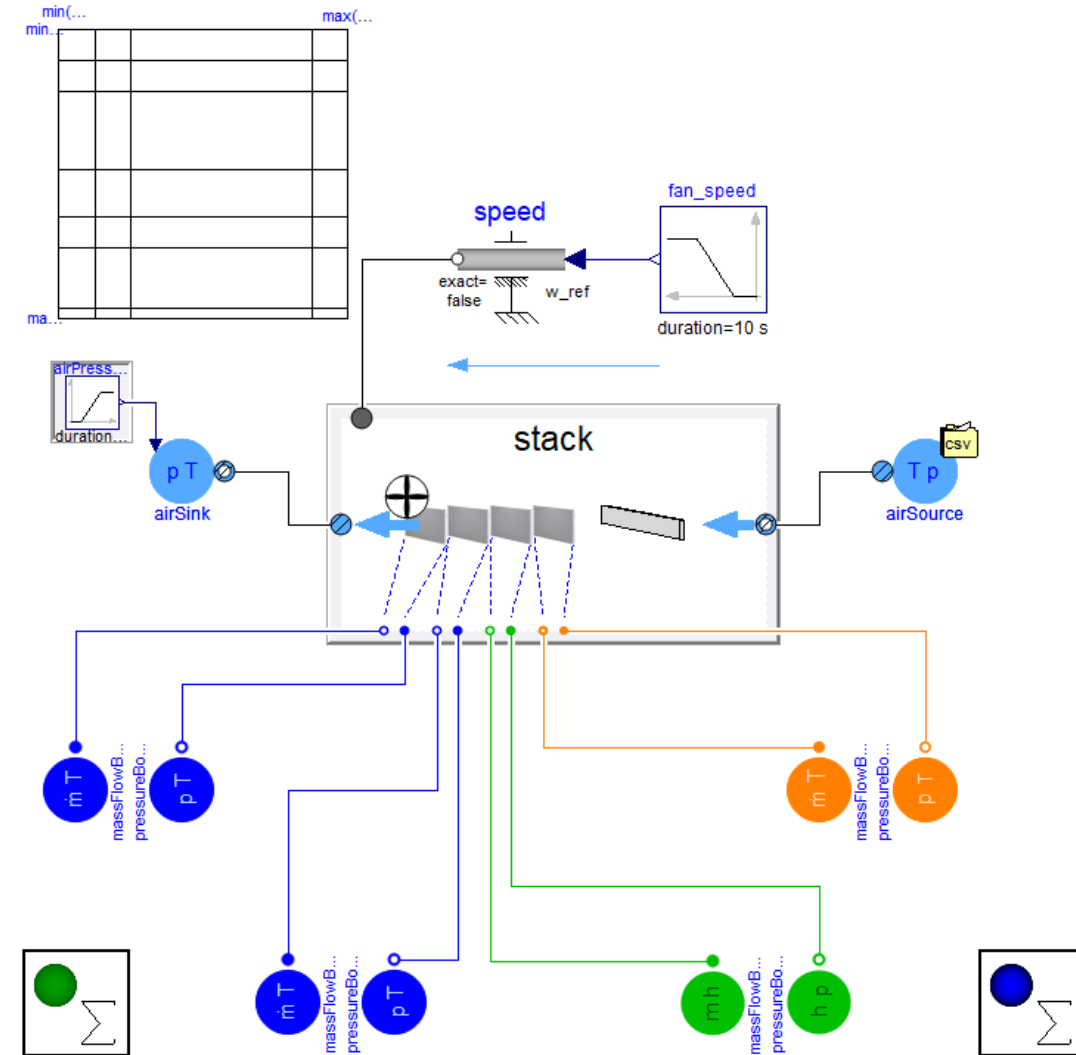




KEY CAPABILITIES

KEY CAPABILITIES

- Detailed geometric models of flat tube and plate heat exchangers
- Geometric friction and heat transfer correlations
- Air models with humidity allows for condensation modeling
- Orientation of flow paths in 3D, 2D resolution of inlet and outlet air conditions.
- Templates for stacking heat exchangers off different types, with fan and obstacle models as well.
- Heat exchanger models taking inhomogeneous air side boundary conditions into account





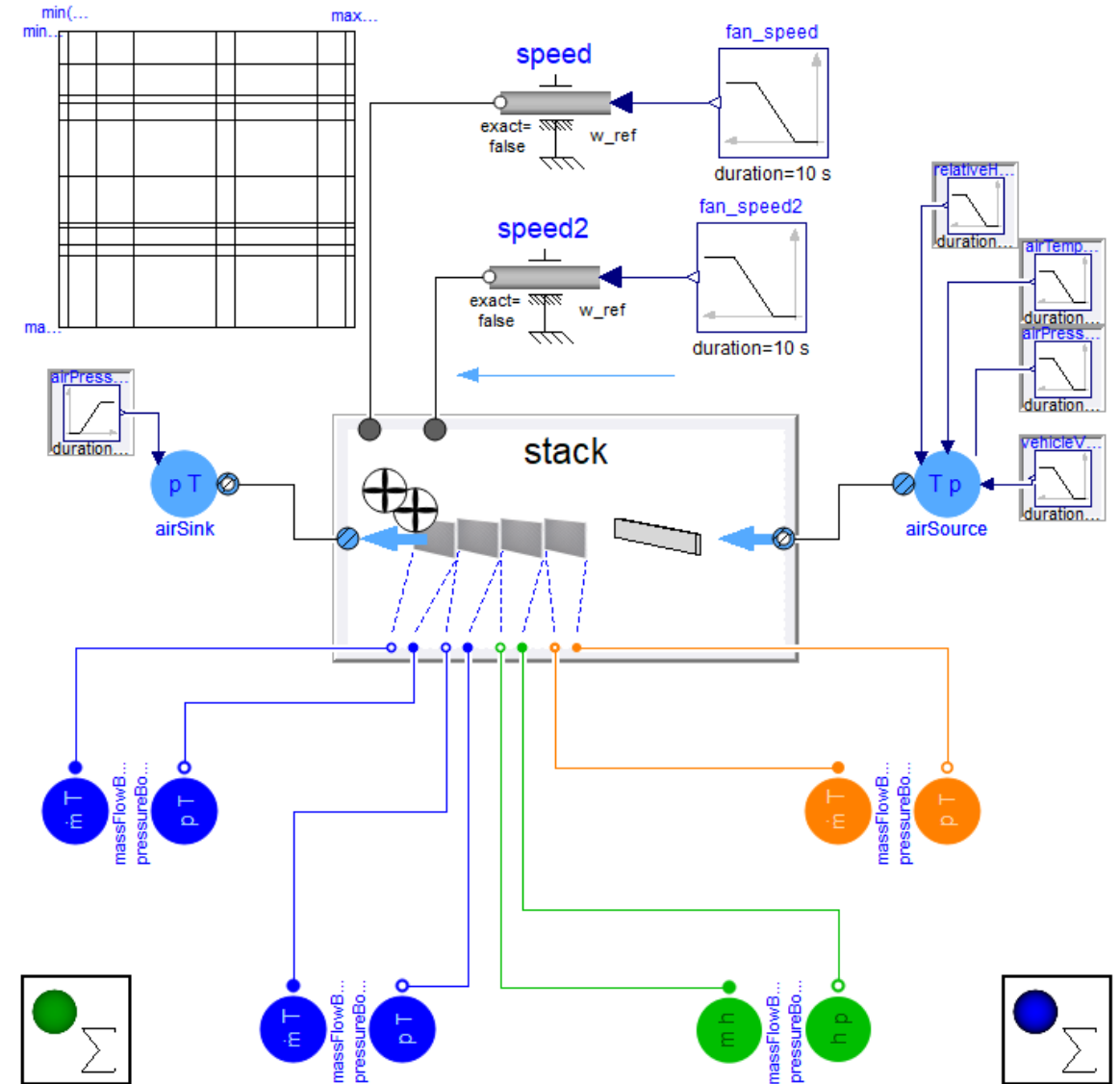
KEY APPLICATIONS

KEY APPLICATIONS

- Stacking
- Cross Flow Flattube HeatExchanger
- Plate HeatExchanger

EXAMPLE: FOUR HEAT EXCHANGERS, TWO FANS AND ONE BAR OBSTACLE IN AIR FLOW

The stack is set up from a template by specifying dimensions and used in this test model. The different colors describe different fluids: Blue: Incompressible liquid, Green: Two-phase fluid, Orange: Gas. Light blue and grey are fans and an obstacle respectively. Air stream grid is created automatically. Homogeneous or inhomogeneous air boundary conditions. Steady-state or dynamic investigations. Export as FMU makes deployment in other tools possible.



EXAMPLE: CROSS FLOW FLATTUBE

- Cross-flow
- Atmospheric air – inhomogeneous air inlet possible
- Liquid, two-phase and gas medium on secondary side
- Geometric friction and heat transfer correlations

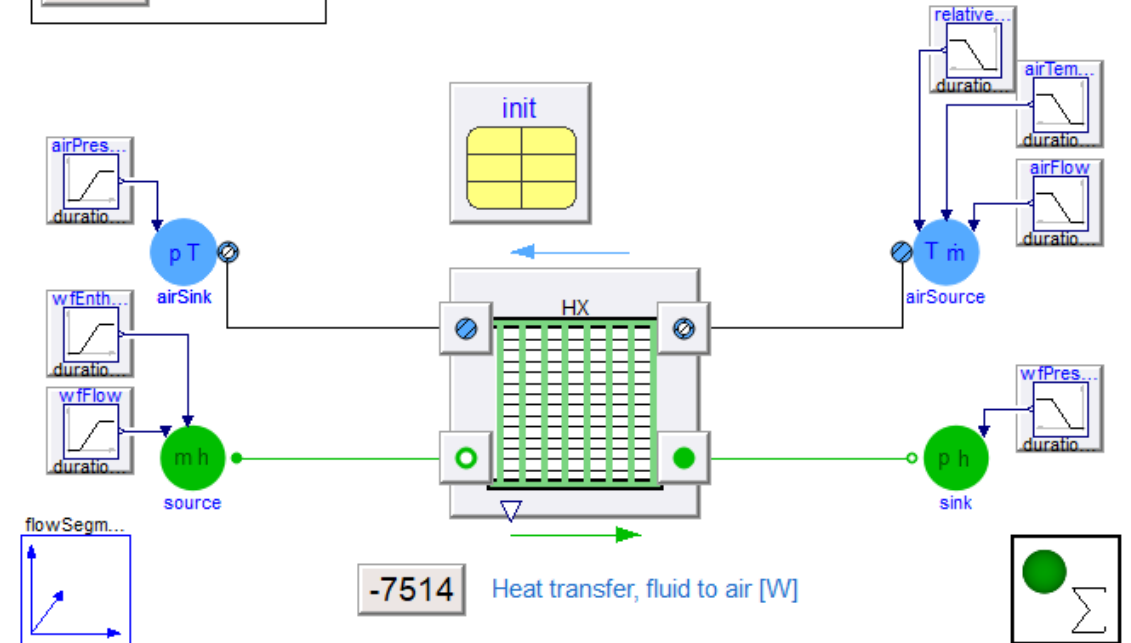
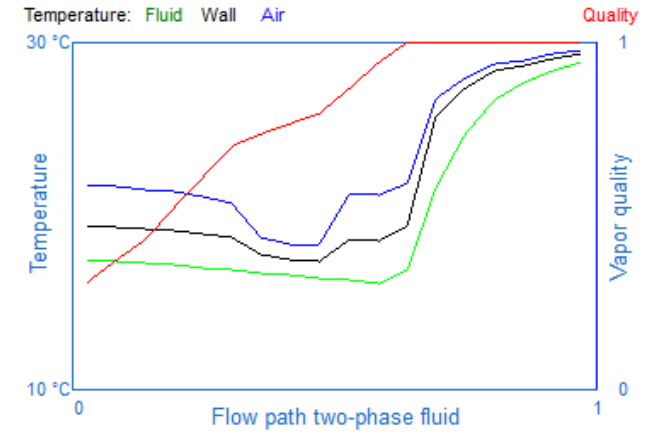
User input

Number of segments, air side

Flow y	X	Flow z
1		1
Temp y	X	Temp z
1		1

Internal pass segmentation

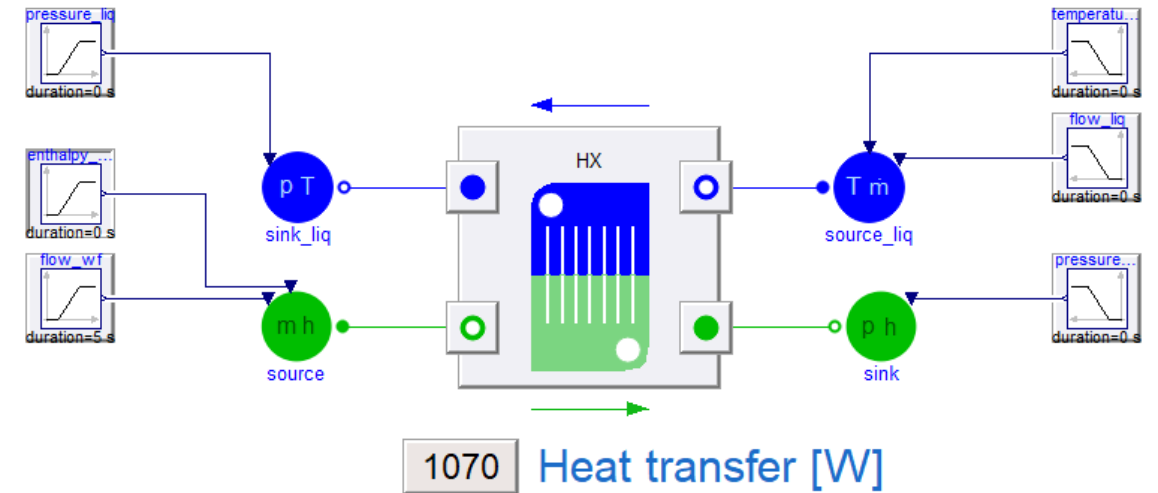
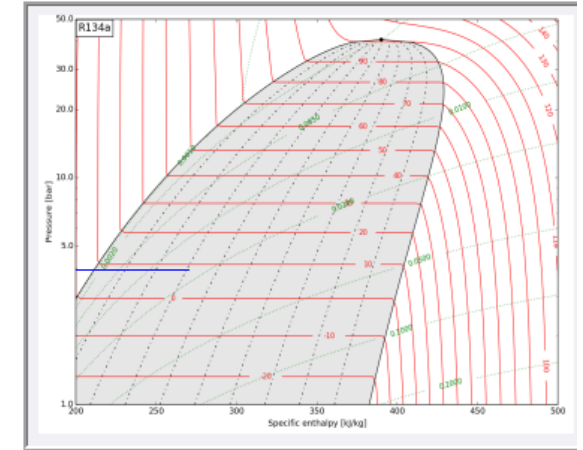
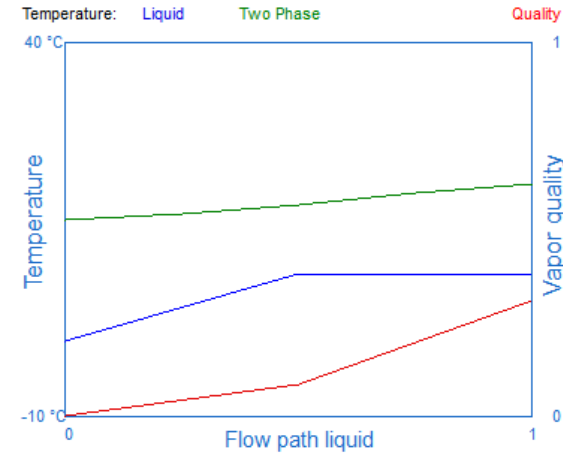
3	Flow direction
1	Orthogonal



EXAMPLE: PLATE HEATEXCHANGER

This experiment is for a liquid - two phase plate heat exchanger with plain plates and counter-current flow.

The visualizer under the heat exchanger reports the heat flow between the liquid and two phase flow. The visualizer above the heat exchanger shows the general temperature profile of the liquid and two phase flow through the header volumes in the heat exchanger.

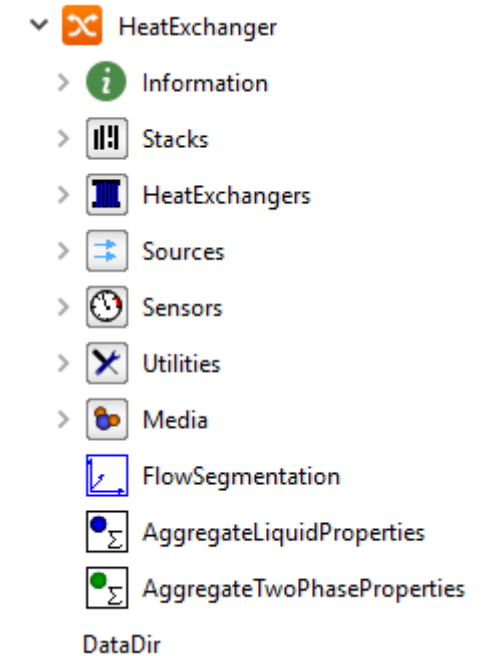




LIBRARY CONTENTS

LIBRARY CONTENTS

- HeatExchangers
- Stacks
- FlowSegmentation
- Media
- Sources and Sensors



LIBRARY CONTENTS

HeatExchangers

There are two subsections of heat exchanger mode

1. Flat tubes
2. Plate

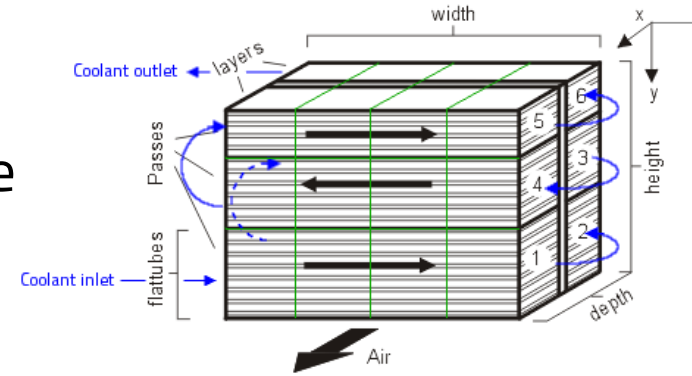
Modeling Approach

- Geometries considered

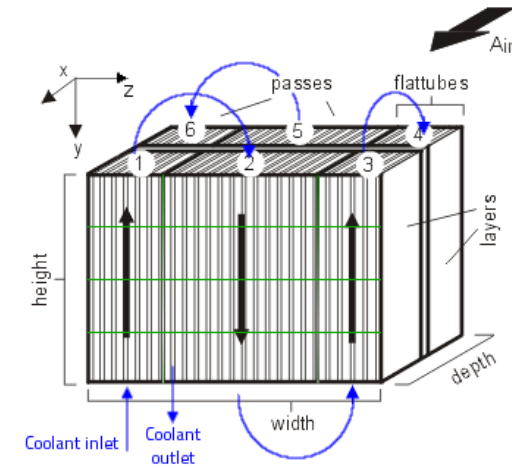
Coolant Segmentation

Coolant path discretization: Unique temperature exposed to the wall in each segment. Several segments per pass and multiple layers are accounted for.

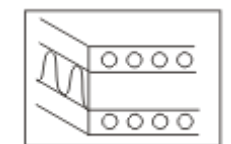
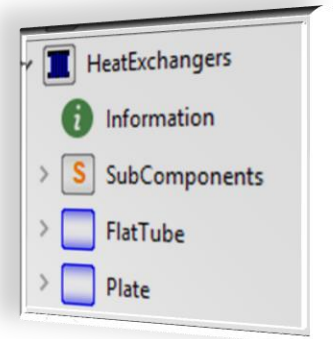
Example: 2-layered, 3 passes per layer, 4 coolant segments per pass.



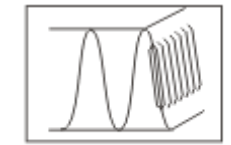
Horizontal



Vertical



Flat tubes

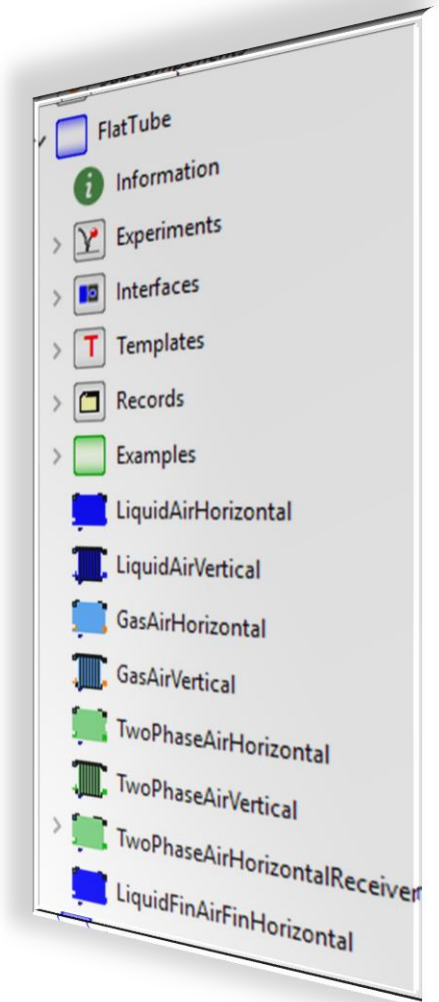
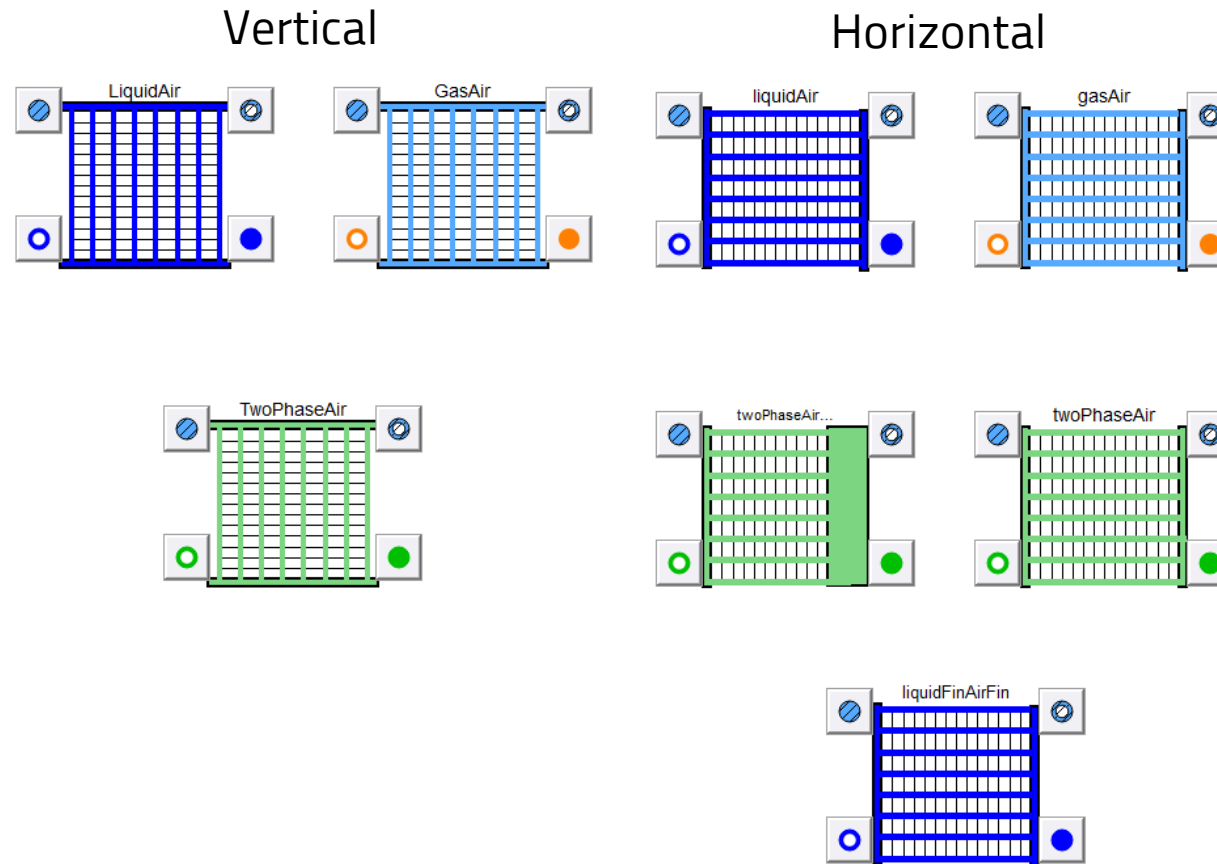


Louvered fins

LIBRARY CONTENTS

FlatTube HeatExchanger

- Cross flow
 - Liquid / two-phase – air (condensing) Microchannel flattube – louvered or offset strip fins
 - Gas – air, fins – fins
 - Liquid – air, fin – fin



LIBRARY CONTENTS

FlatTube HeatExchanger

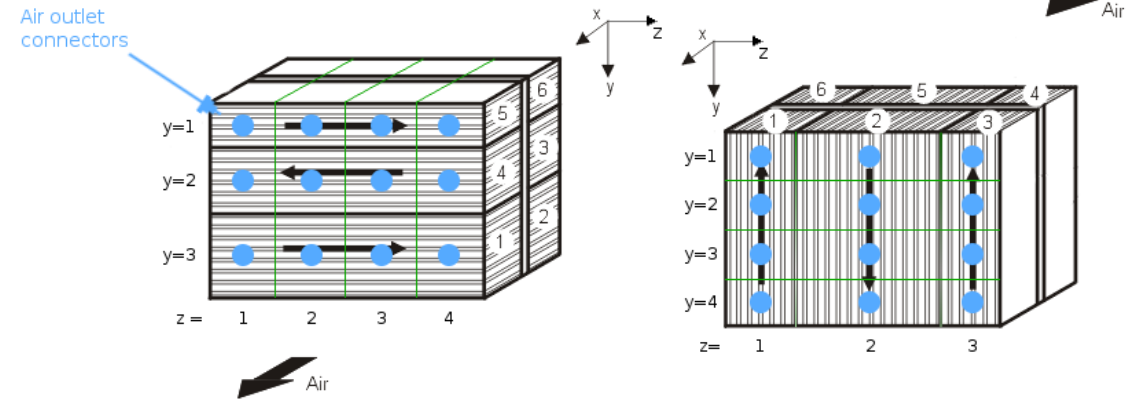
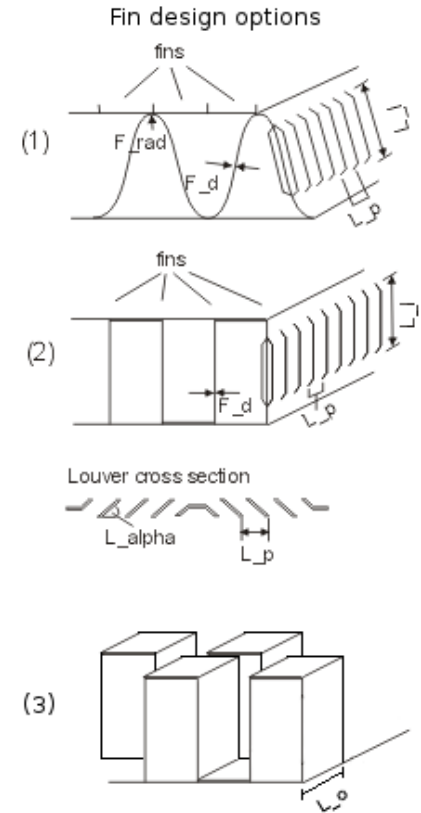
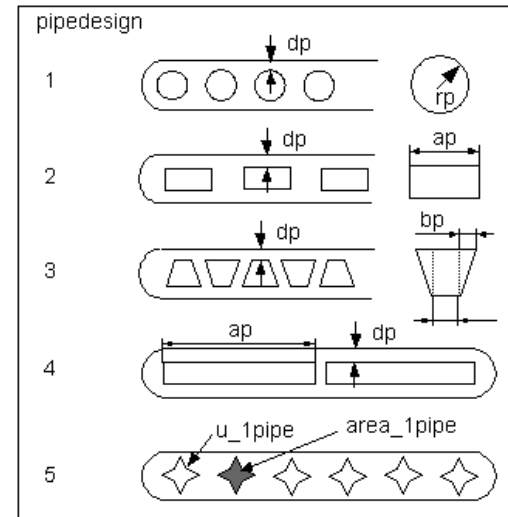
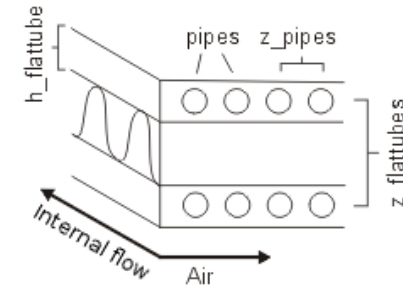
Channel geometries

Several geometries are possible.

- Free flow area, heat transfer area, etc. calculated automatically
- Geometric friction and heat transfer correlations included

Air Side Interface

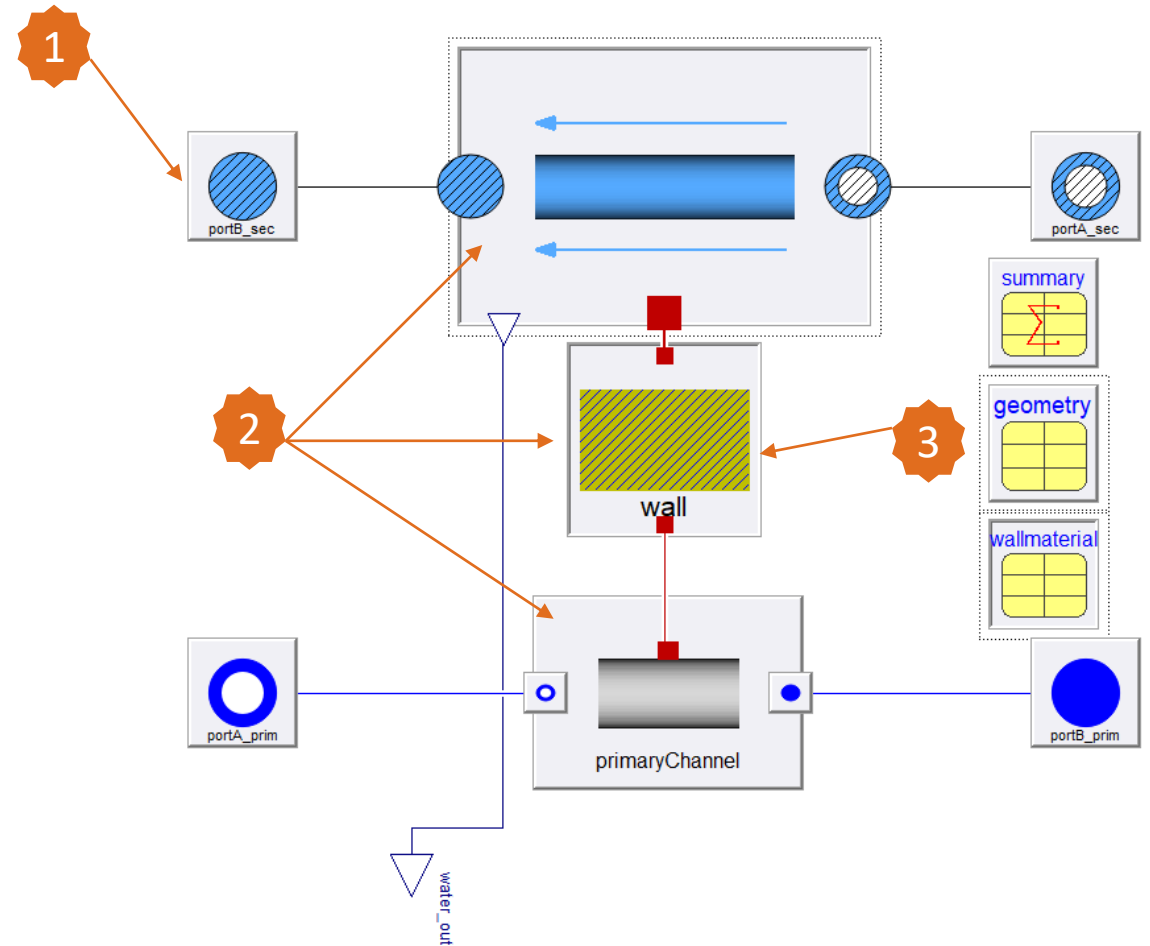
- The air flow through each segment assumes uniform flow and temperature.



LIBRARY CONTENTS

FlatTube HeatExchanger

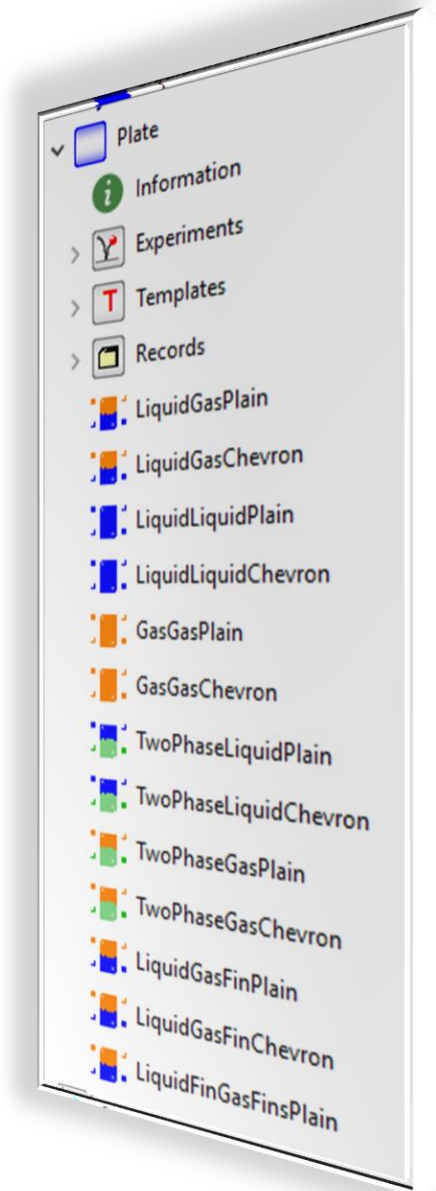
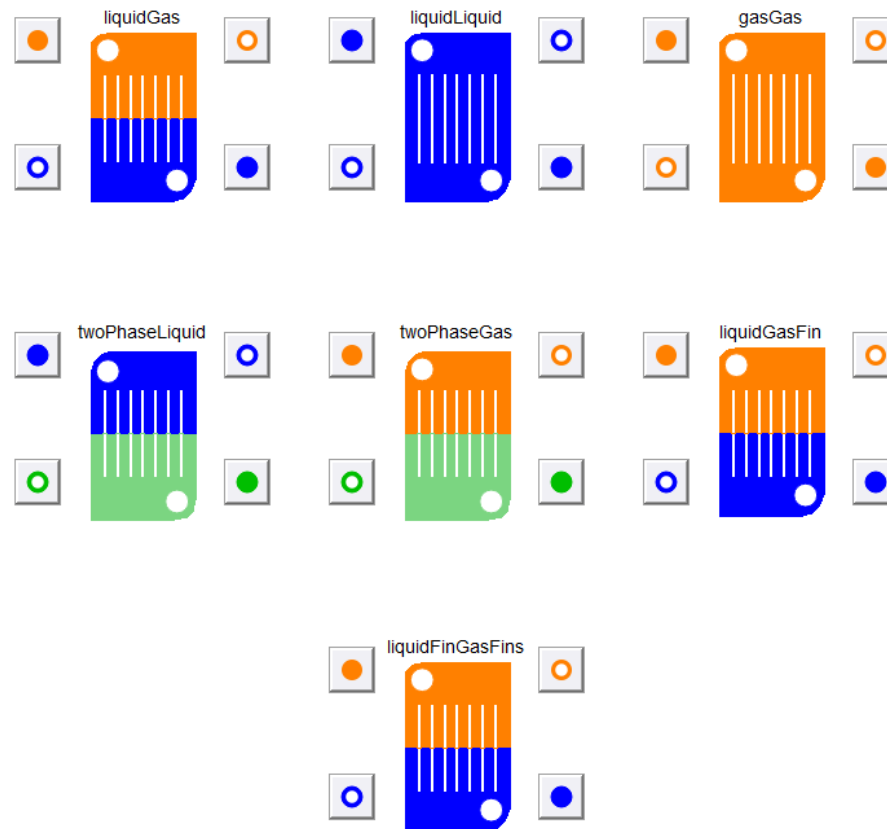
1. External connector: Flow segmented by stream tubes, high resolution temperature profile, full stream field represented (not limited by HX outer edges)
2. Replaceable components
3. Discretized wall
 - Supports multiple layers. Arbitrary pass ordering
 - Support discretization of passes along and orthogonal to flow direction



LIBRARY CONTENTS

Plate HeatExchanger

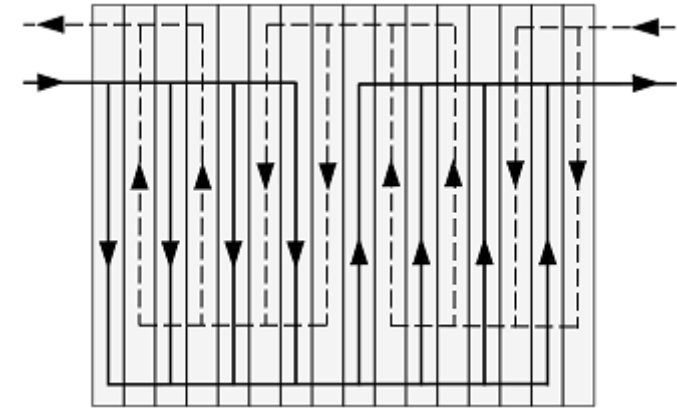
- Co- / counter-flow
 - Plate heat exchangers, plain & Chevron any combination of liquid, gas and two phase fluid
 - Plate – fin and fin – fin for gas and liquid
 - Any combination of local co- / counter flow arrangements and different number of passes allowed



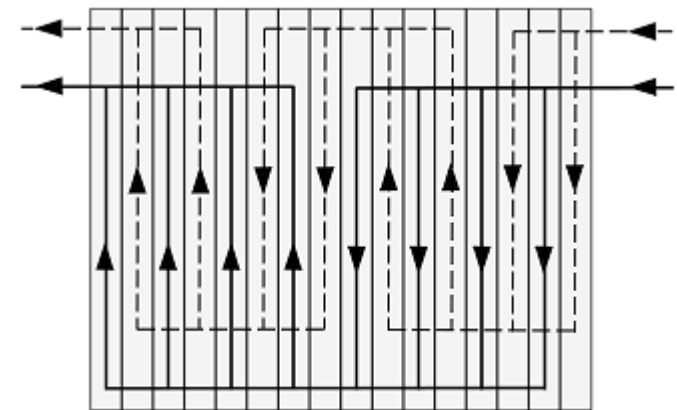
LIBRARY CONTENTS

Plate Flow Scheme

- The flow scheme is defined as arrays:
 - Passes_A = {2,2,2,2}
 - Passes_B = {4,4}
- Total number of channels for A and B must be equal



Counter flow

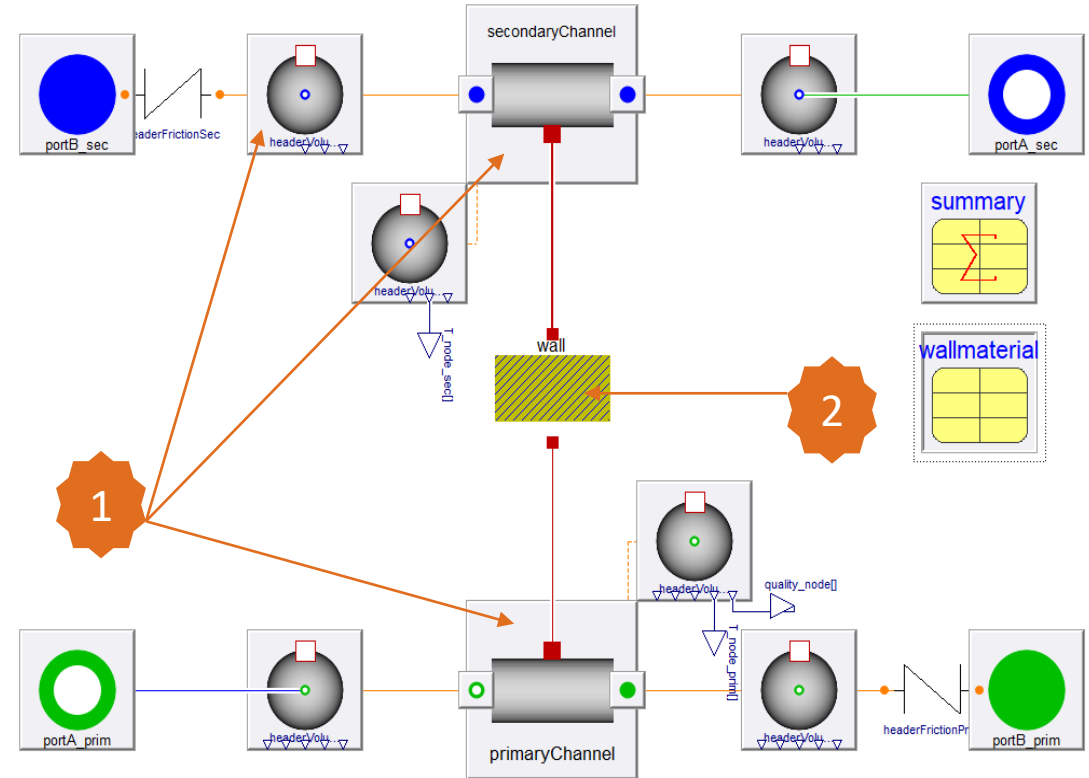


Cocurrent flow

LIBRARY CONTENTS

Plate HeatExchanger

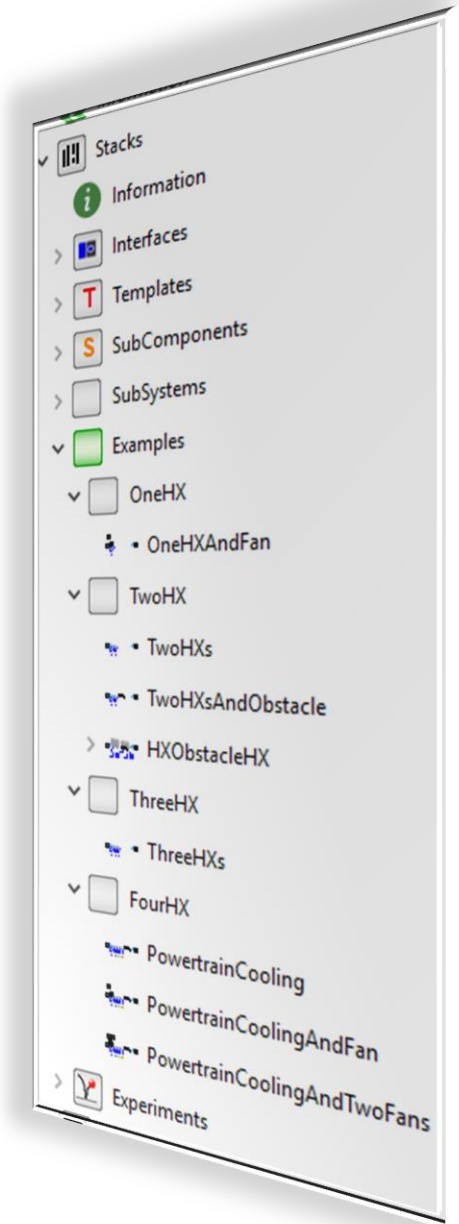
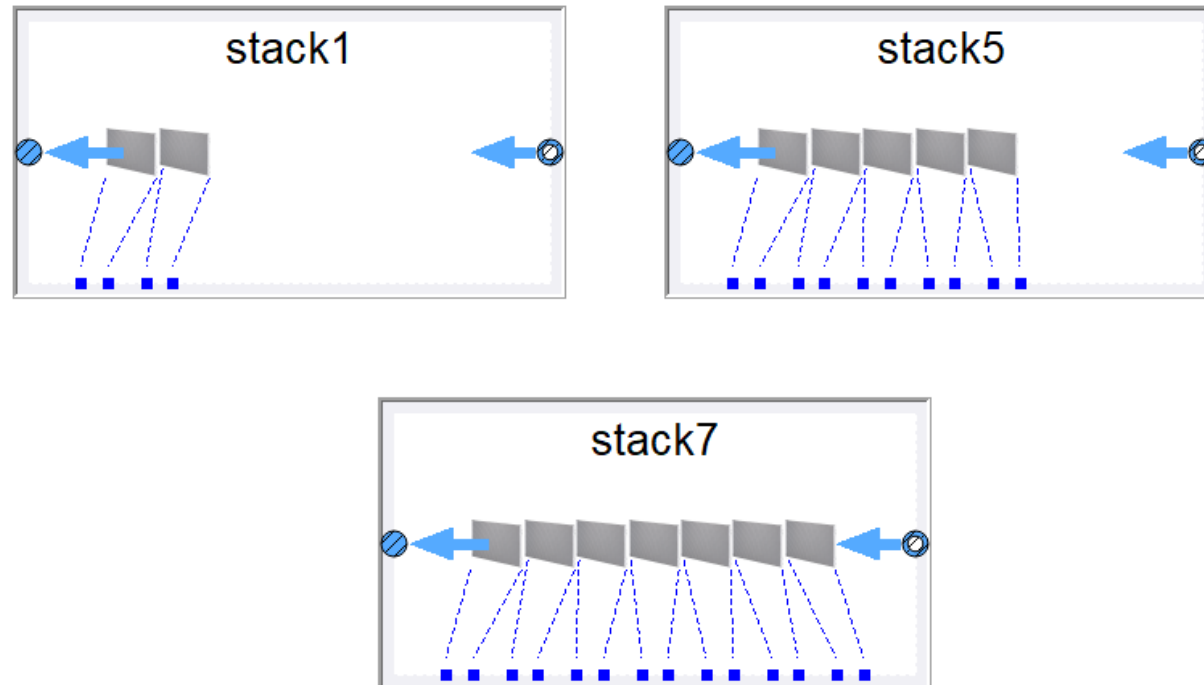
- Plates with counter flow or concurrent flow
 - Often uses pressurized media
 - Plain or Chevron plate surfaces
1. Replaceable components
 2. Discretized wall



LIBRARY CONTENTS

Stack

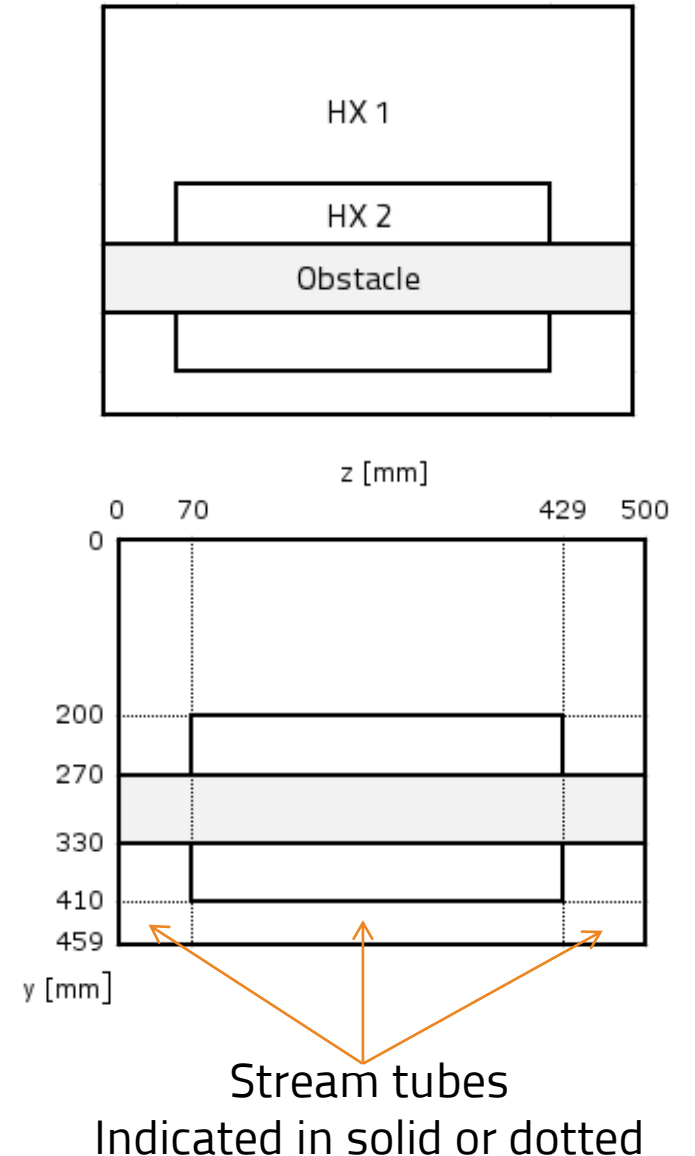
- In the Stacks package, there are different templates and experiments describing multiple different setups. This allows the user to get a better understanding of how to use the Stack components.



LIBRARY CONTENTS

Stream Tubes

- For stack models, stream tubes concept is introduced along air flow. The segment edges are aligned with the heat exchanger components boundaries and depend on component size and position only.
- A given number of additional points can be added in the largest gaps.
- For each stream tube, uniform flow rate and pressure drop is assumed. The temperature distribution is independent of the stream tubes.

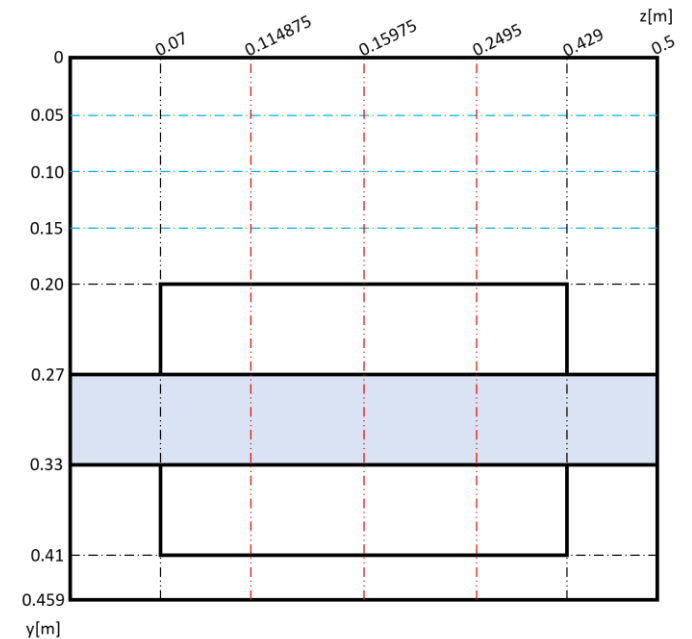


LIBRARY CONTENTS

Stream Tubes

- Stream tube grid points are automatically added at component boundaries, and a given number of additional points can be added in the largest gaps.
- The blue and red color indicates the additional grid points in y and z directions

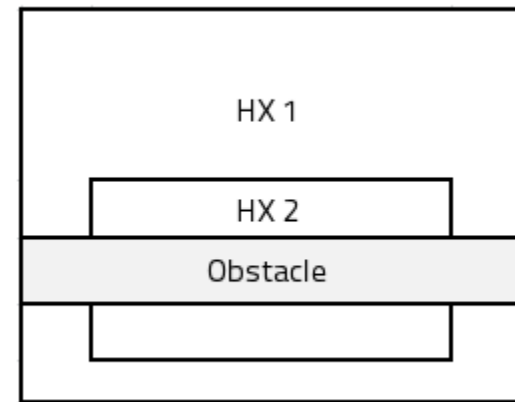
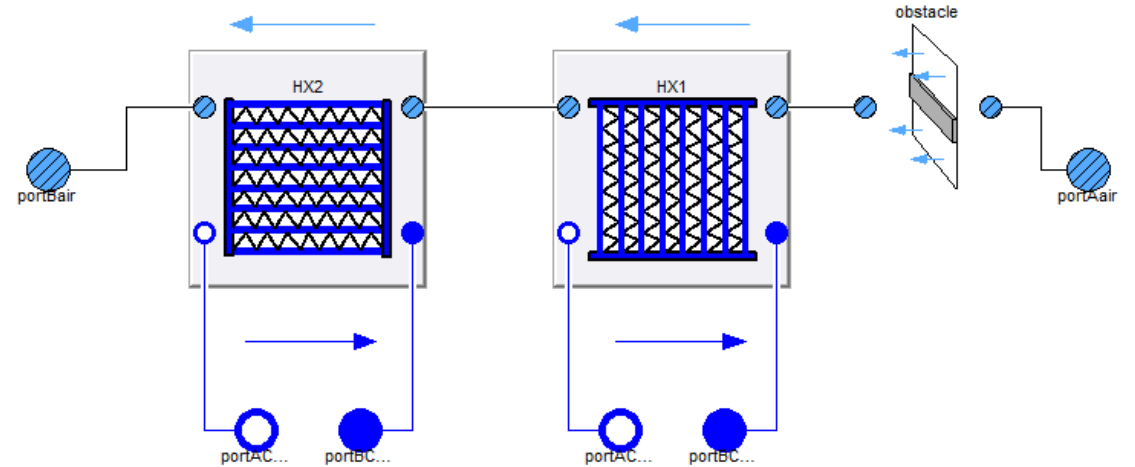
flowSegmentation	<input type="text"/>	▶	
use_additional_corners	<input type="text" value="false"/>	▶	If true, also use additional_corners when computing flow segmentation
additional_corners	<input type="text" value="[0, 0, 0, 0]"/>	▶ m	Coordinates for the corners of the components not in the stack
Refinement			
yAddGridPoints	<input type="text" value="3"/>	▶	Number of additional y-axis flow grid points
zAddGridPoints	<input type="text" value="3"/>	▶	Number of additional z-axis flow grid points
splitComponent_yID	<input type="text" value="1"/>	▶	Identify heat exchanger where additional y-grid points would be added, 0: Splits grid at largest intervals
splitComponent_zID	<input type="text" value="2"/>	▶	Identify heat exchanger where additional z-grid points would be added, 0: Splits grid at largest intervals
Advanced			
yMinGridPoints	<input type="text" value="0"/>	▶	Minimum number of y-axis flow grid points desired
zMinGridPoints	<input type="text" value="0"/>	▶	Minimum number of z-axis flow grid points desired



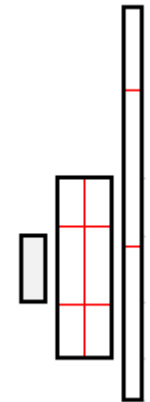
LIBRARY CONTENTS

Stack

- Example: Two heat exchangers without common edges. Partly covered by an obstacle causing lower flow rate through a segment.
- Air flow straight through the heat exchanger stack is assumed.
- The stack can now be built by directly connecting components. The component connectors are independent of the internal component segmentation and includes the flow bypassing the component



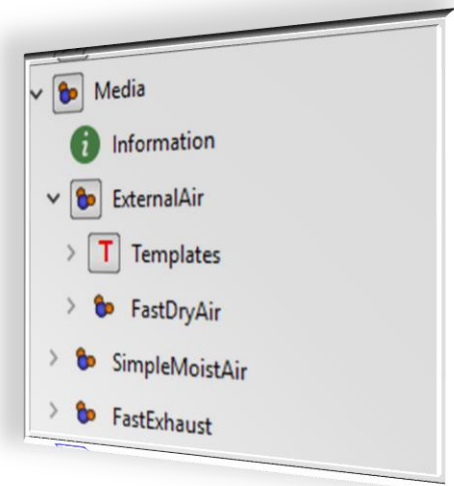
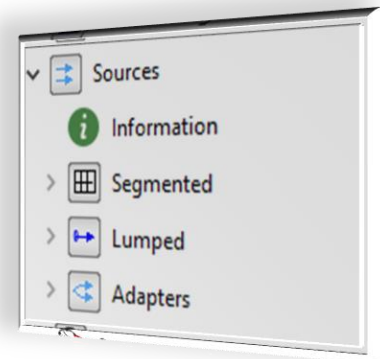
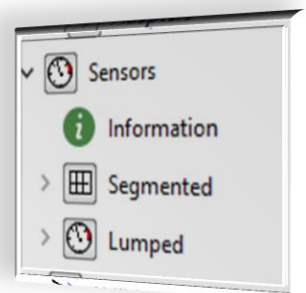
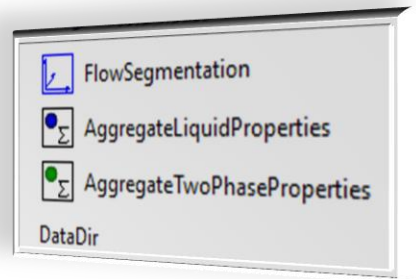
Front view



Side view
Passes in red

LIBRARY CONTENTS

Media and other basic components

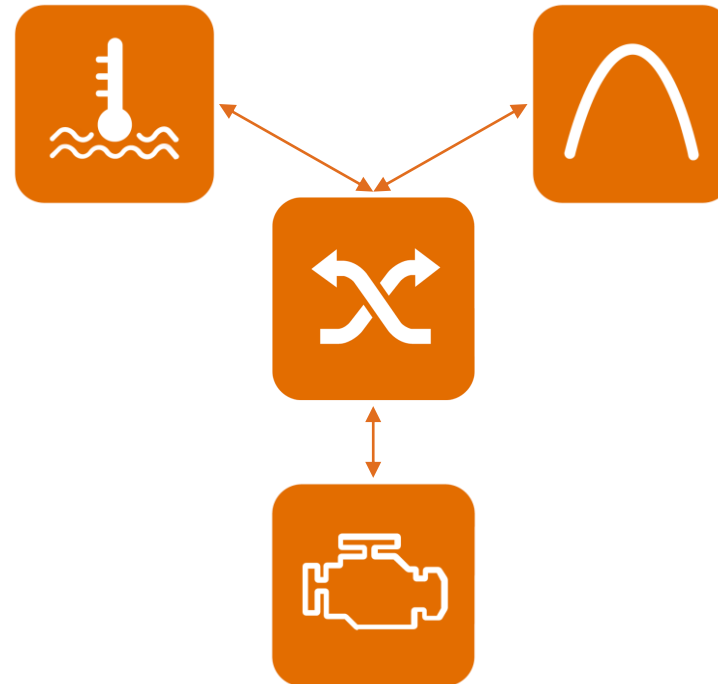




MODELON COMPATIBILITY

RECOMMENDED MODELON LIBRARY COMPATIBILITY

- HeatExchanger Library components are seamless compatible with Liquid cooling Library, VaporCycle Library, Engine Dynamics Library.
- HeatExchanger Library compatible with Batch simulation in
 - MATLAB
 - Python
 - Excel



EXAMPLE : BATCH SIMULATION IN FMI ADD-IN FOR EXCEL

- Monte Carlo on the HX effectiveness multipliers (uniform distribution between 0.6 & 1) and the flow rate scaling factors (normal distribution with mean 1 and std dev 0.1)
- Constant Speed drive cycle at 120 kph with fan off and 50% grill opening (trade-off identified earlier)



		Default	Case 1	Case2	Case3	Case4	Case5	Case6	Case7	Case8	Case9	Case10	Case11	Case12	Case13	Case14	Case15	Case16			
7																					
8	Settings																				
9	Start time		0																		
10	Stop time		5000																		
11	FMU		C:\Users\Chandrasekar\Documents\Projects\F302-PreSales\VTM\VTMDriveCycleVTM_ConstantSpeed_CS.fmu																		
12	Log level		Info																		
13	Enable		TRUE																		
14	Output points		100																		
15	Timeout		0																		
16																					
17	Indata																				
18	Name	Variabili	Typ	Unit																	
19	stack.heat_exchanger_1_eff_multipli	parameter	Real		1	0.8822	0.8134	0.8318	0.7158	0.7208	0.9099	0.6056	0.9043	0.9258	0.8836	0.6181	0.7656	0.945	0.9162	0.7434	0.9848
20	stack.heat_exchanger_3_eff_multipli	parameter	Real		1																
21	airFlowDistribution.flowRateScale[1]	parameter	Real		1																
22	airFlowDistribution.flowRateScale[3]	parameter	Real		1																
23	fan_command	continuou	Real		0																
24	grillPositionCmdNorm	continuou	Real		0.5																
25																					
26	Outdata																				
27	Name	Variabili	Typ	Unit																	
28	fan_command	continuou	Real		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	grillPositionCmdNorm	continuou	Real		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
30	signalBus.VDL_trm_oil_temp	continuou	Real	K	345.4	345.4	345.4	345.4	345.4	339.1	345.3	345.4	345.4	345.4	345.4	345.4	345.4	345.4	345.4	345.4	345.4
31	signalBus.VDL_eng_cool_temp	continuou	Real	K	367.2	372.5	370.6	380.1	379.7	365.7	391.8	366	364.9	367.2	390.3	375.9	364	365.3	377.3	361.6	
32																					
33	Message					OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
34																					
35	signalBus.VDL_trm_oil_temp		deg C		72.244	72.241	72.237	72.24	72.246	65.985	72.113	72.224	72.233	72.268	72.215	72.233	72.224	72.209	72.234	72.242	
36	signalBus.VDL_eng_cool_temp		deg C		94.072	99.311	97.405	106.95	106.56	92.532	118.68	92.823	91.713	94.028	117.11	102.79	90.897	92.192	104.14	88.412	
37																					
38																					
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Experiment settings

Parameter modifiers

Output of the experiment at the stop time



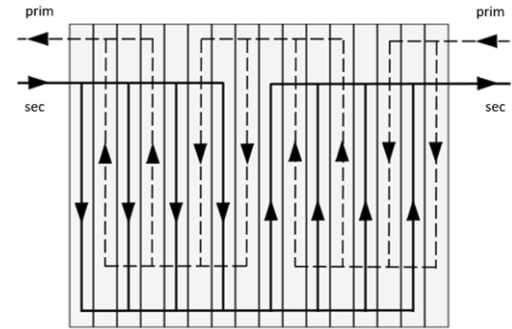
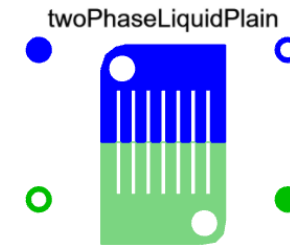
LATEST RELEASE



RELEASE: 2021.2

New Features

- Two new two-phase-two-phase counter-flow heat exchangers with a plain plate/chevron surface developed



Enhancements

- Plate heat exchanger geometry records descriptions improved
- The model components (HX, source blocks, correlations, geometry) of the flat tube and plate heat exchanger experiment are made replaceable