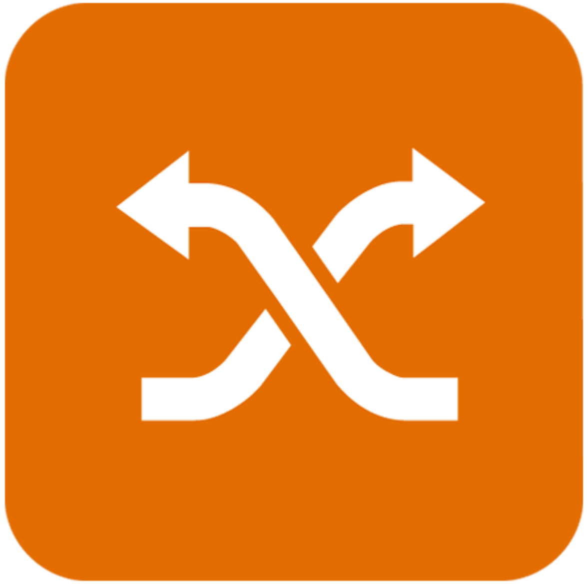
HEAT EXCHANGER LIBRARY

Overview

Modelon

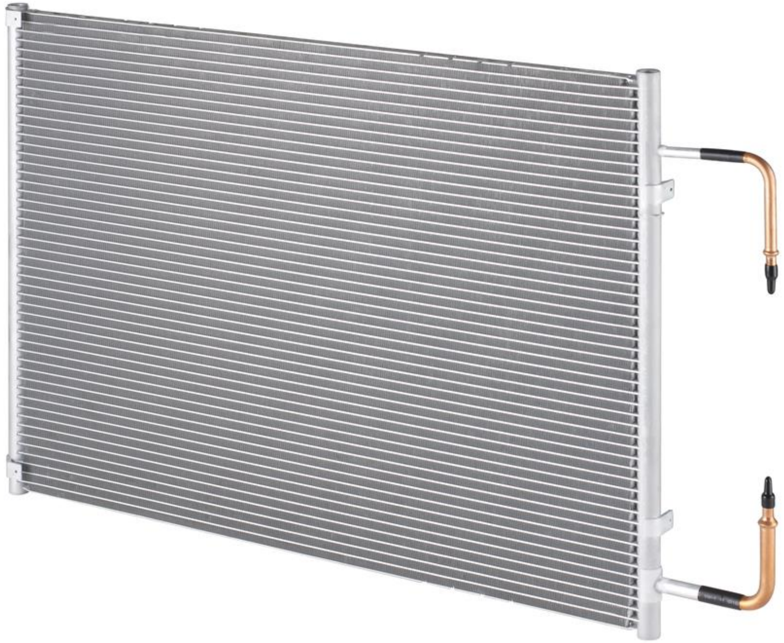
AGENDA

- ❑ 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



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KEY BENEFITS

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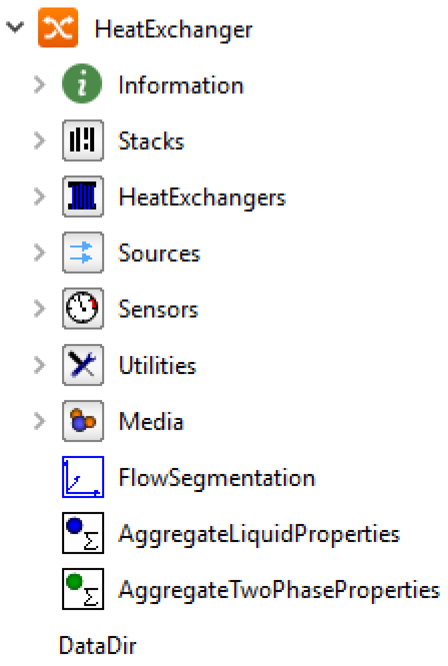
- Geometric models of flat tube and plate heat exchangers
- Geometric friction and heat transfer correlations
- Air side interface allows heat exchanger stacking
- Automatic area fraction calculations on flow segment level
- 2D – discretized and lumped flow source and sensor components
- Plug-and-play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



KEY CAPABILITIES

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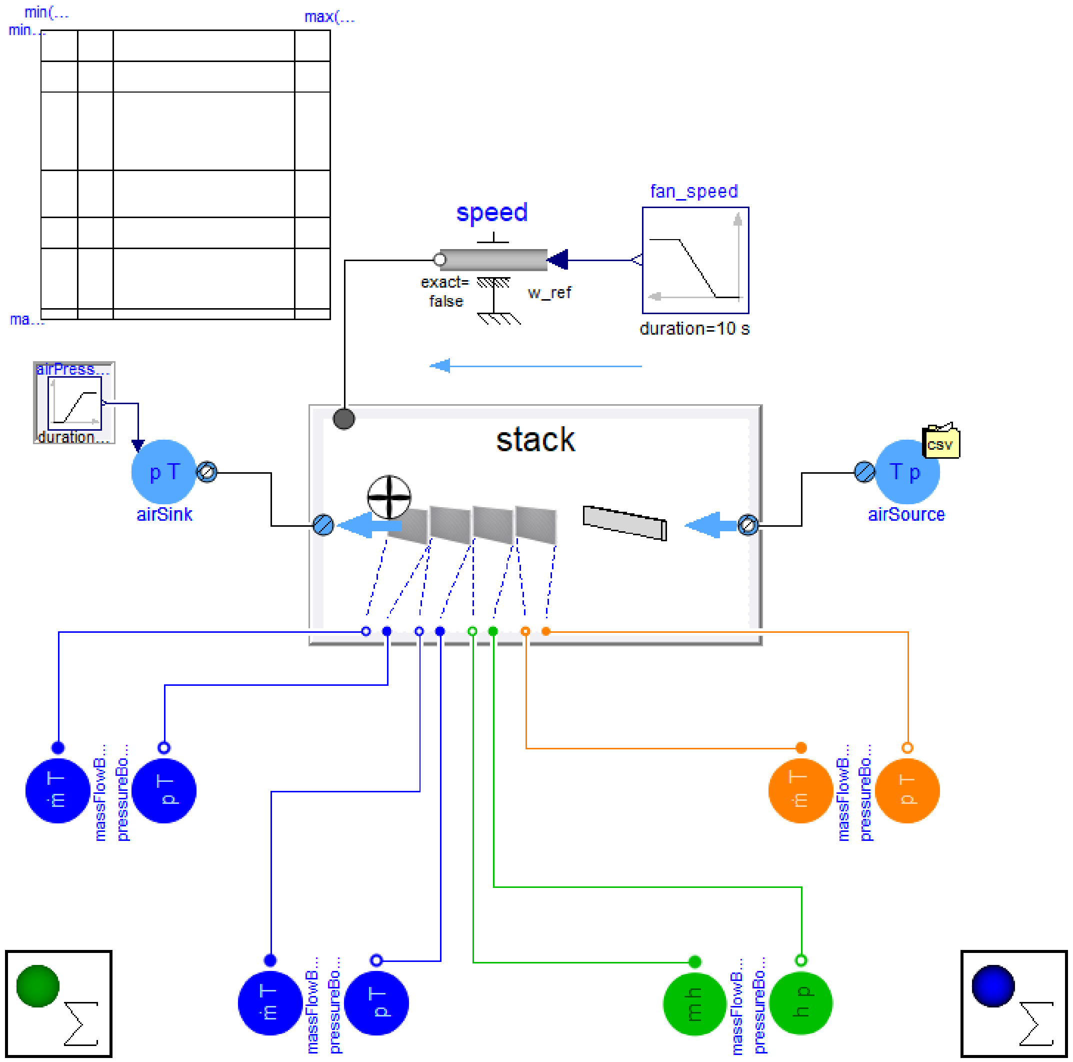
- Detailed geometric models of flat tube and plate heat exchangers
- Geometric friction and heat transfer correlations
- Air models with humidity allows for condensation modeling
- Orientation of flow paths in 3D, 2D resolution of inlet and outlet air conditions.
- Templates for stacking heat exchangers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



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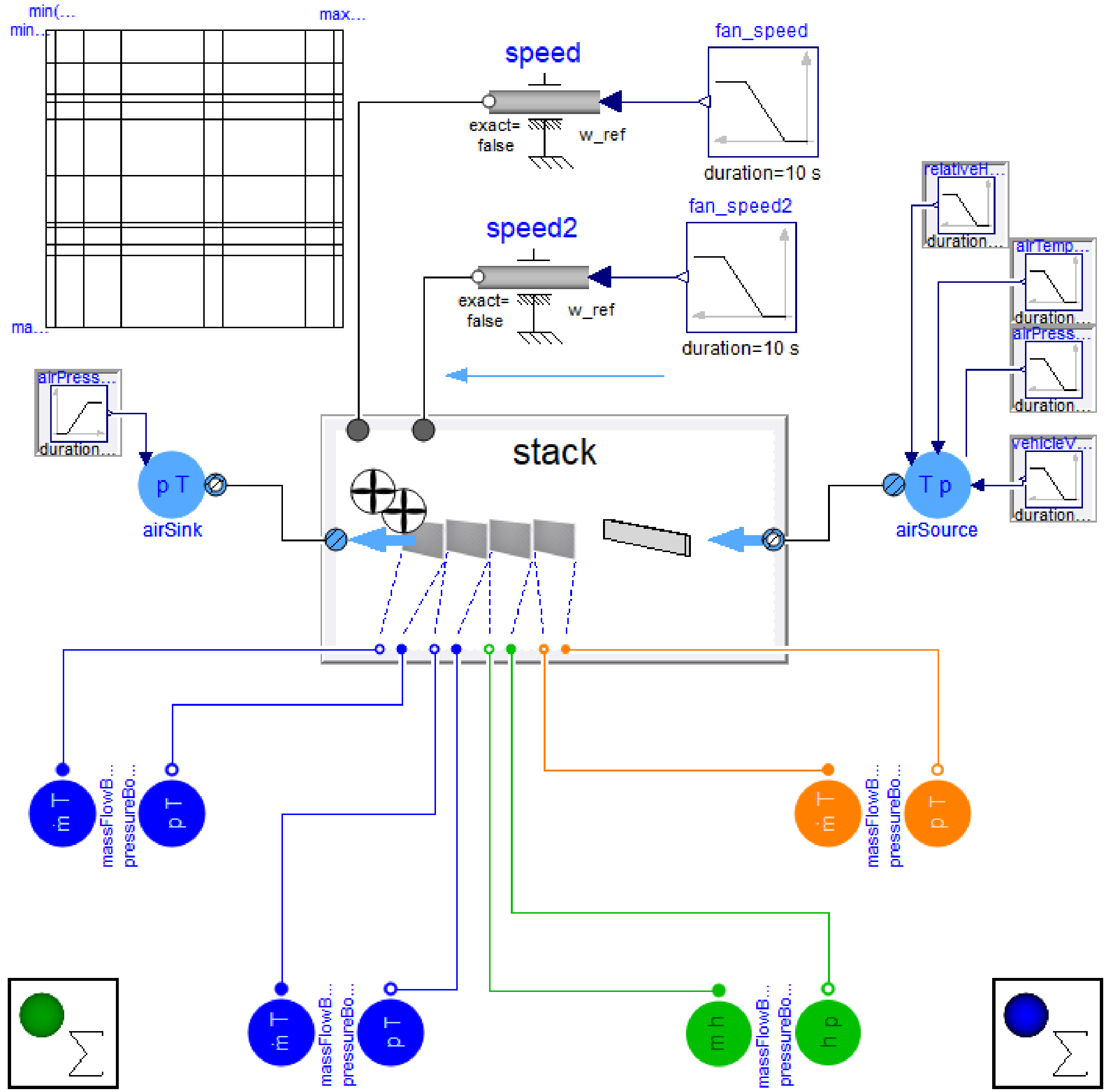
KEY APPLICATIONS

KEY APPLICATIONS

- Stacking
- Cross Flow Flattube HeatExchanger
- Plate HeatExchanger

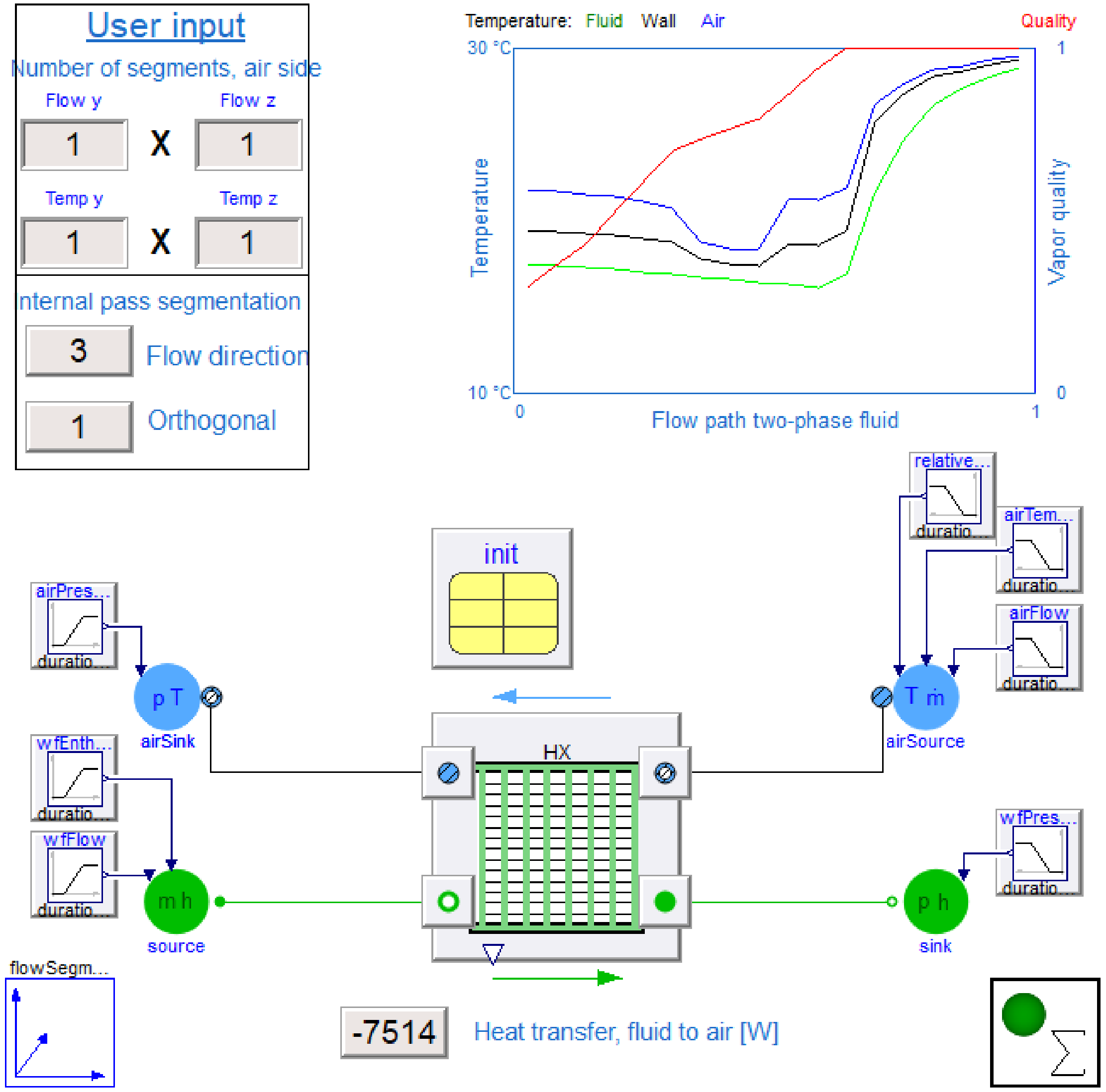
EXAMPLE: FOUR HEAT EXCHANGERS, TWO FANS AND ONE BAR OBSTACLE IN AIR FLOW

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



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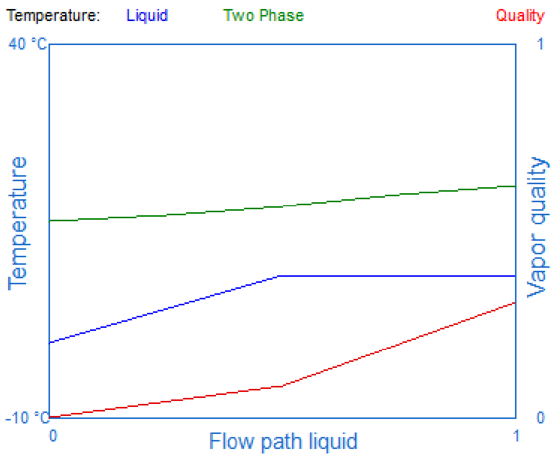
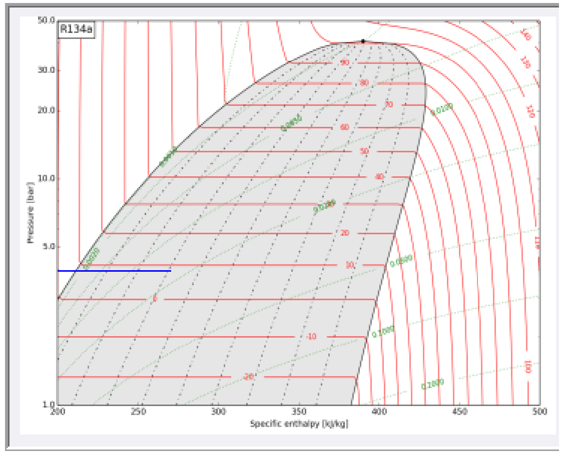
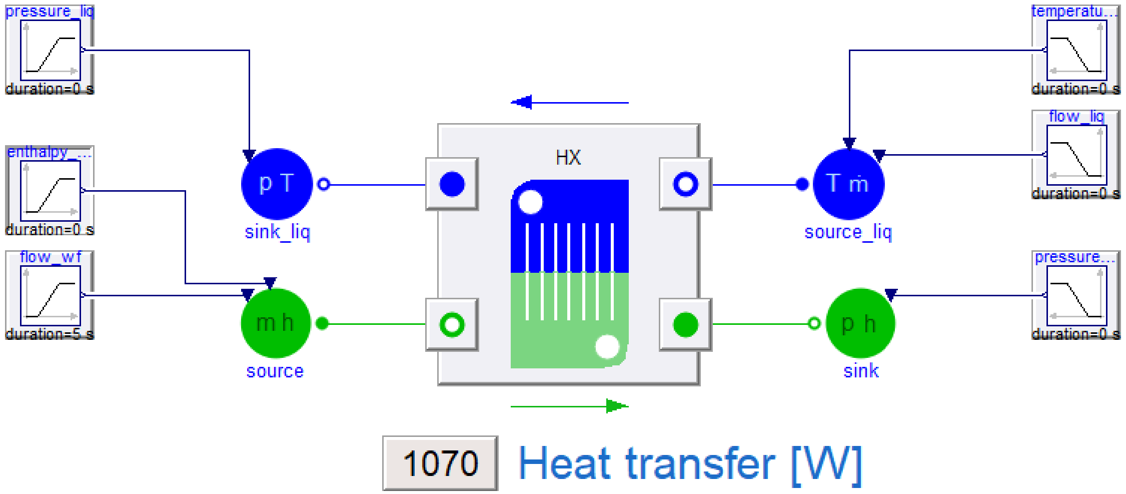
EXAMPLE: PLATE HEATEXCHANGER

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.



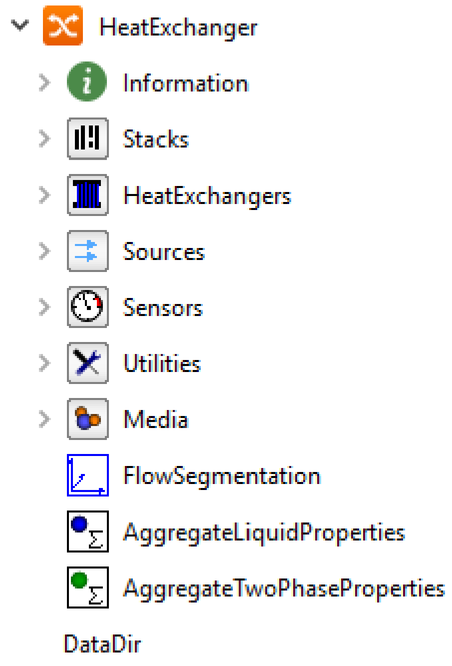




LIBRARY CONTENTS

LIBRARY CONTENTS

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



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HeatExchangers

There are two subsections of heat exchanger mode

1. Flat tubes
2. Plate

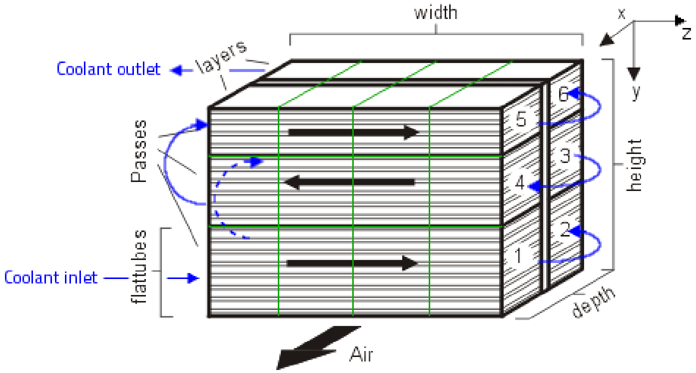
Modeling Approach

- Geometries considered

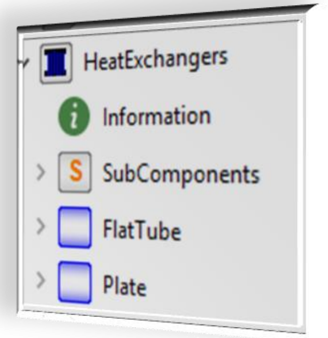
Coolant Segmentation

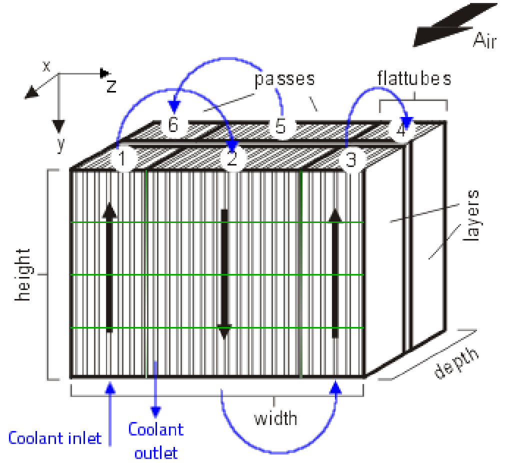
Coolant path discretization: Unique temperature exposed to the wall in each segment. Several segments per pass and multiple layers are accounted for.

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

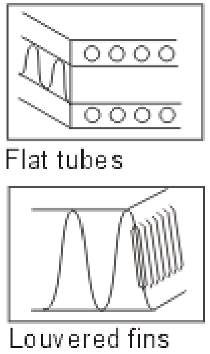


Horizontal





Vertical



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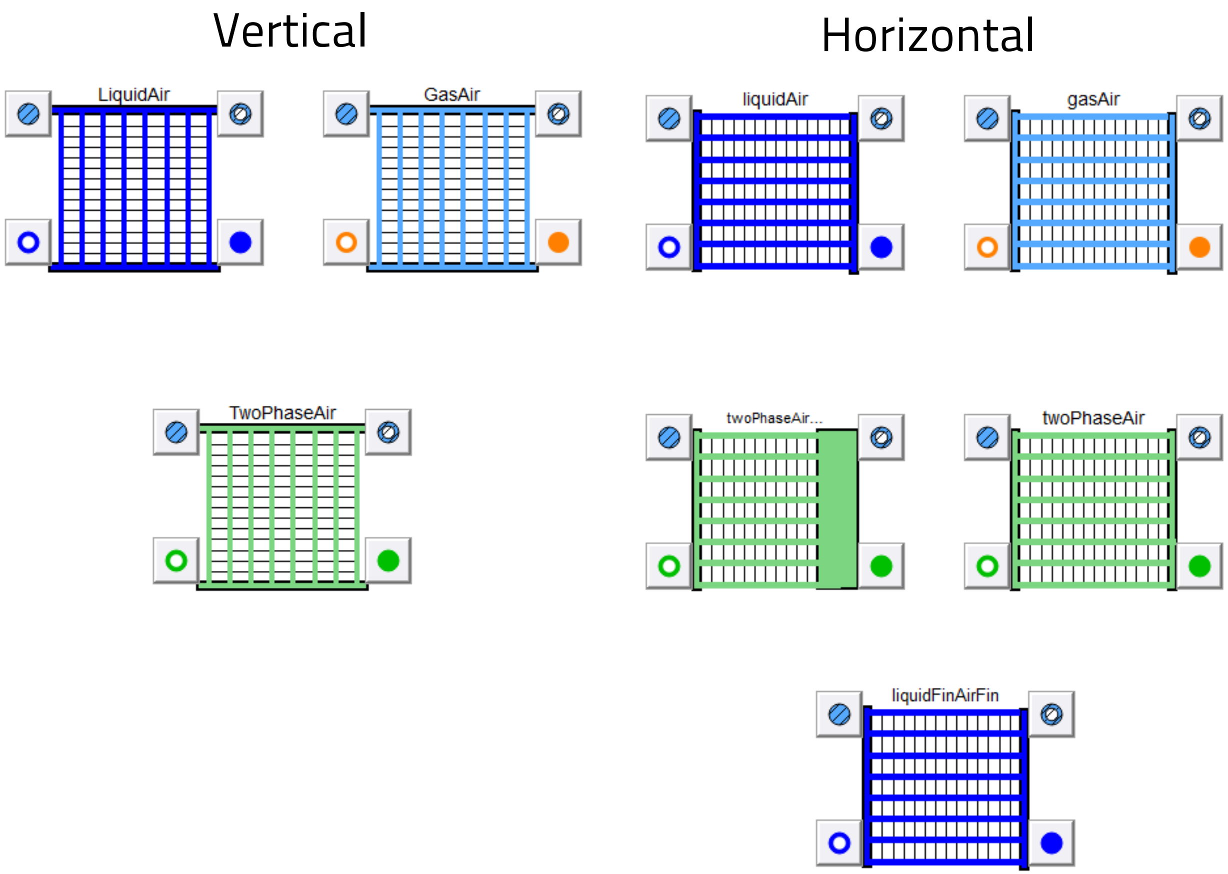
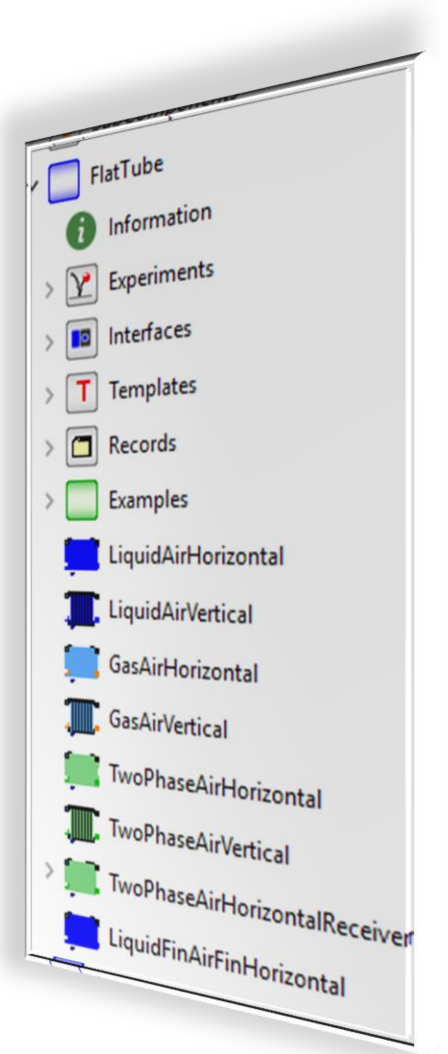
FlatTube HeatExchanger

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





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FlatTube HeatExchanger

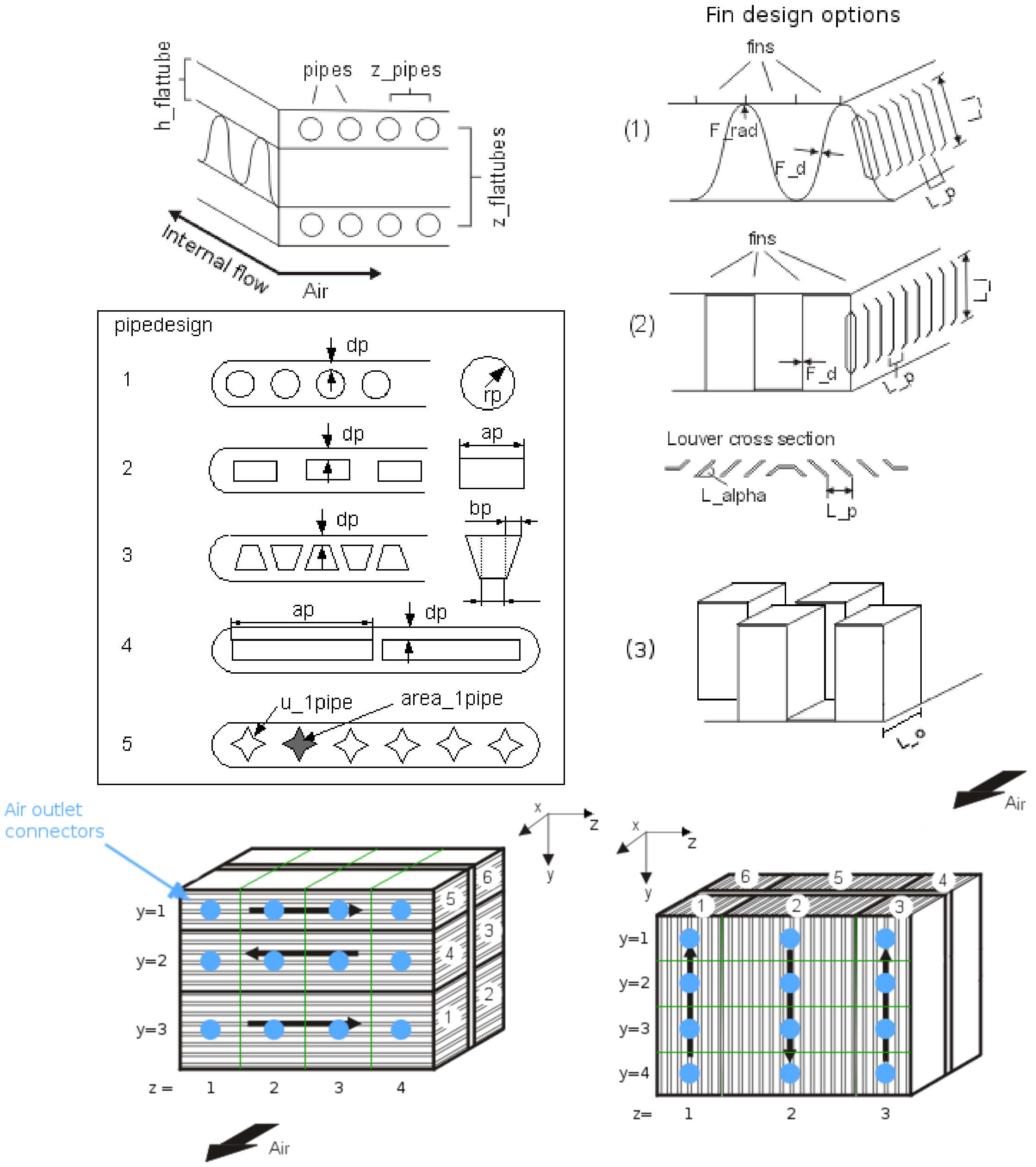
Channel geometries

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.



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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

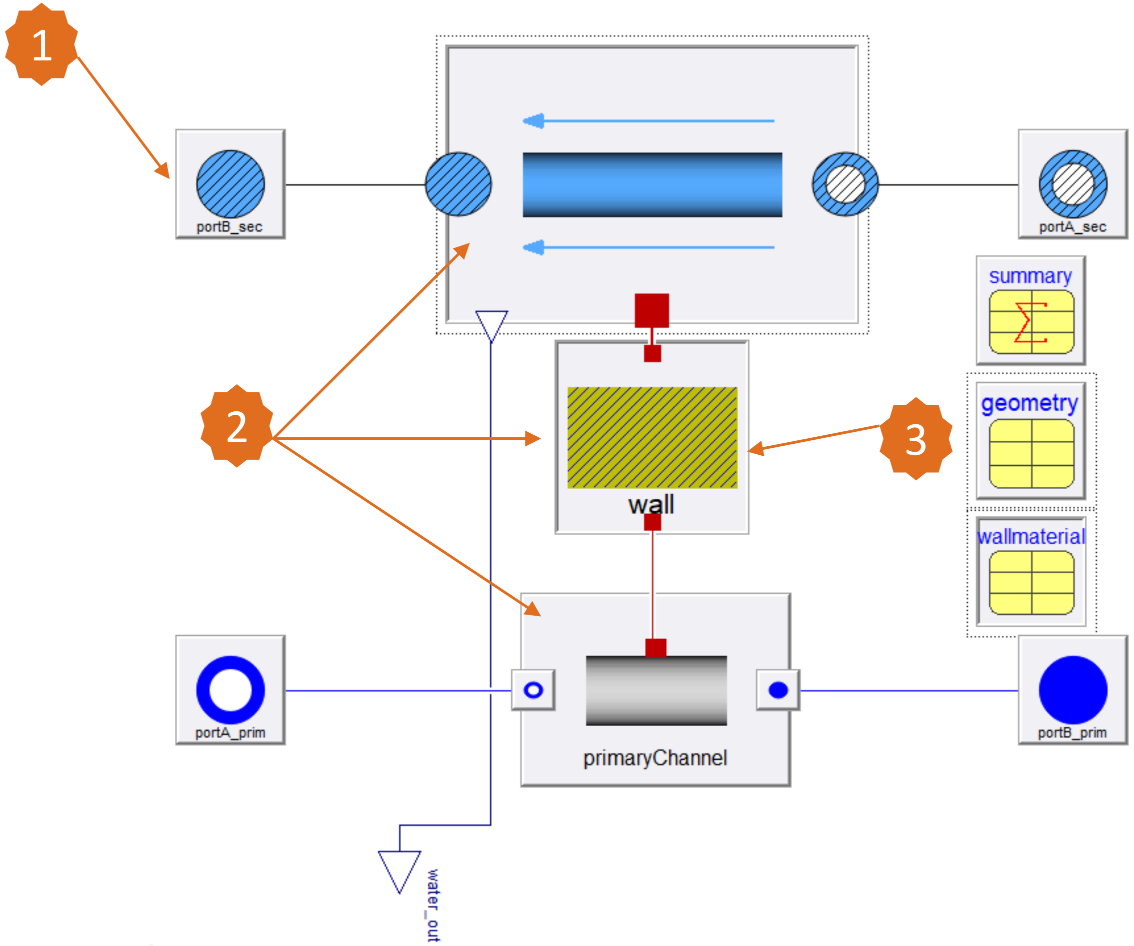

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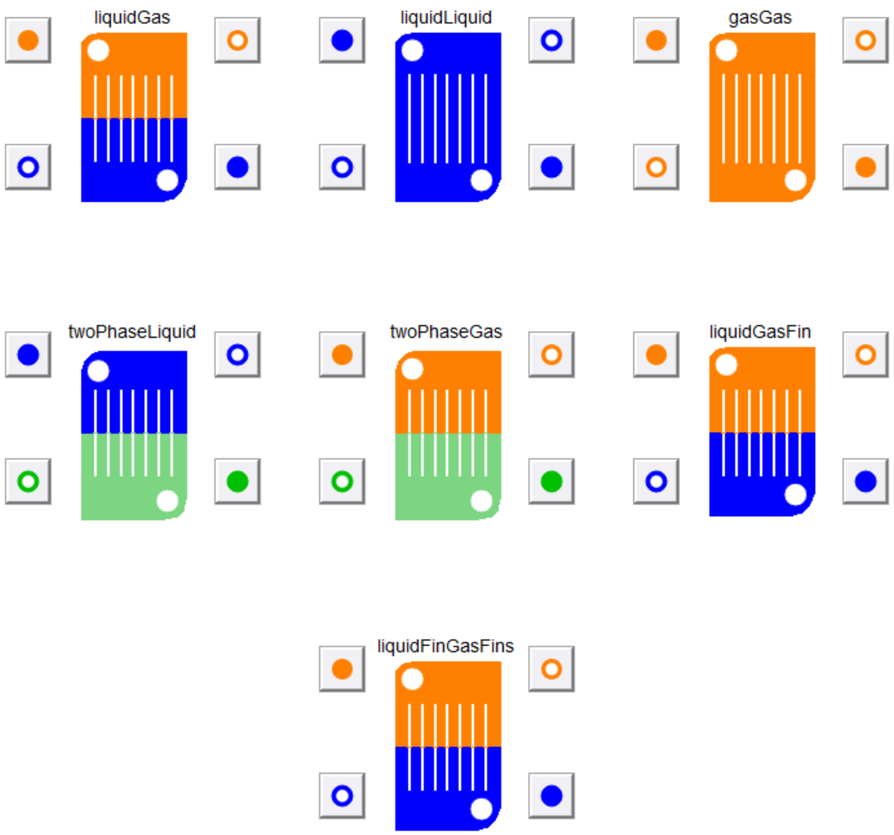
Plate HeatExchanger

- 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



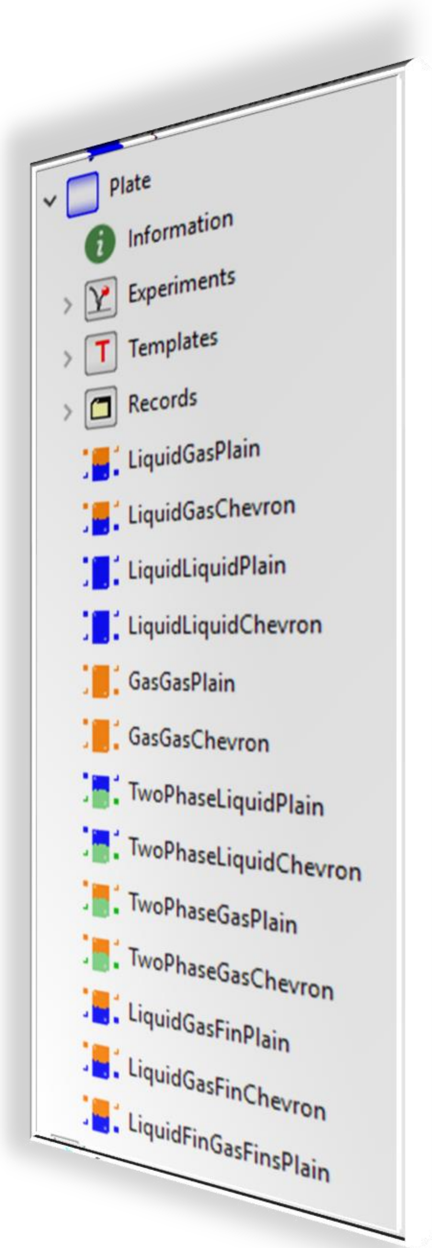


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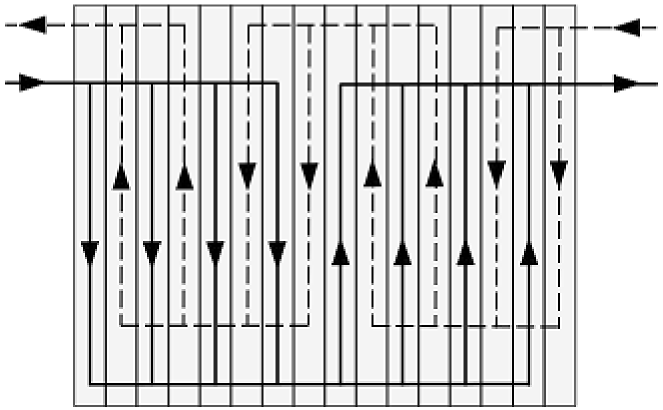
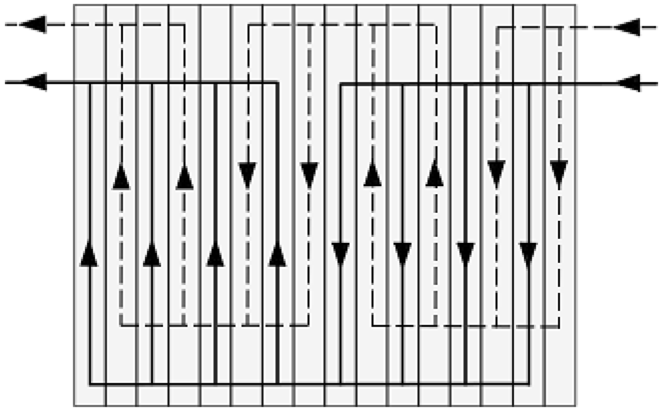
Plate Flow Scheme

- 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

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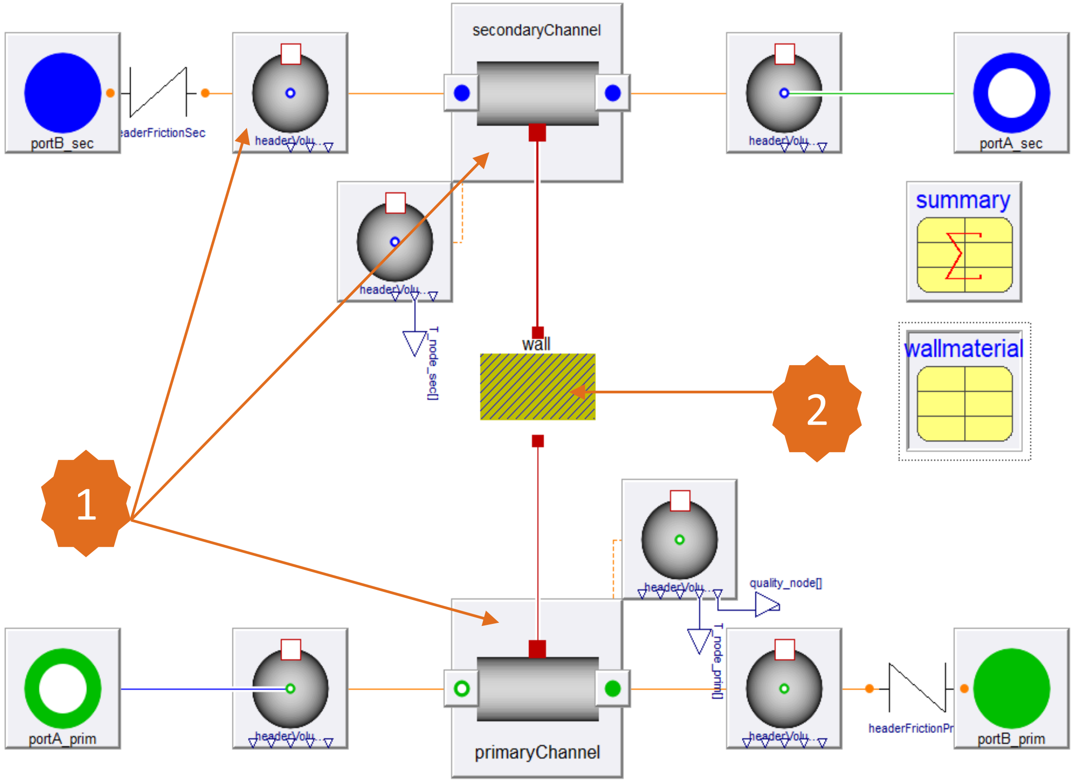
Plate HeatExchanger

- Plates with counter flow or concurrent flow
- Often uses pressurized media
- Plain or Chevron plate surfaces

1. Replaceable components
2. Discretized wall



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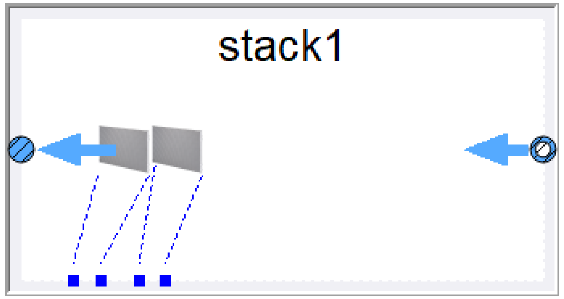
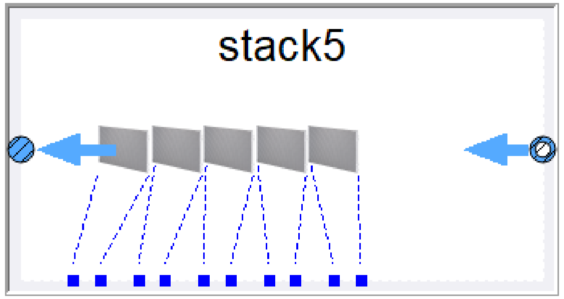
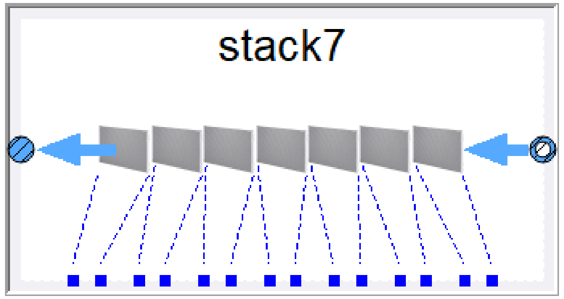
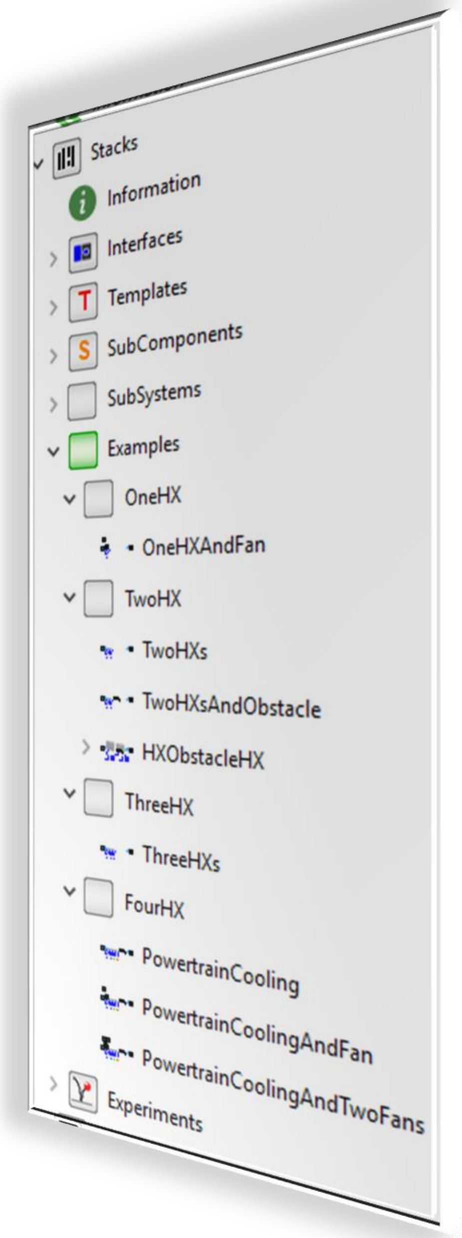
Stack

- 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.









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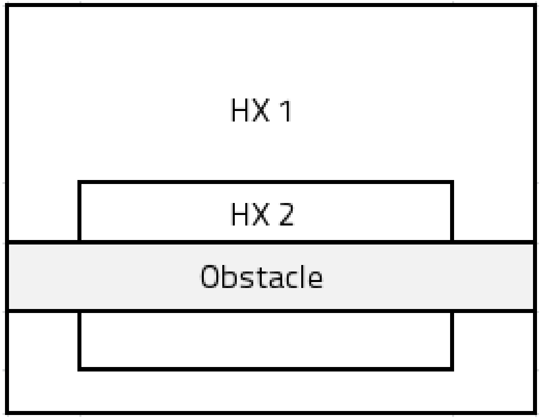
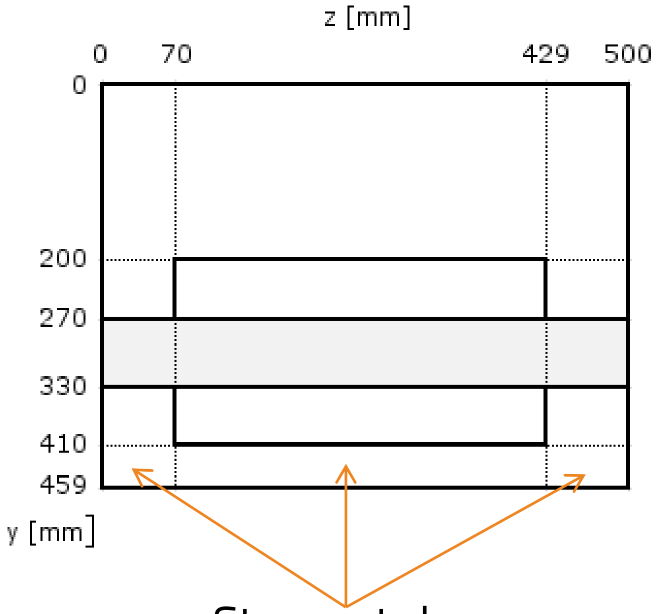
Stream Tubes

- 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.





Stream tubes
Indicated in solid or dotted

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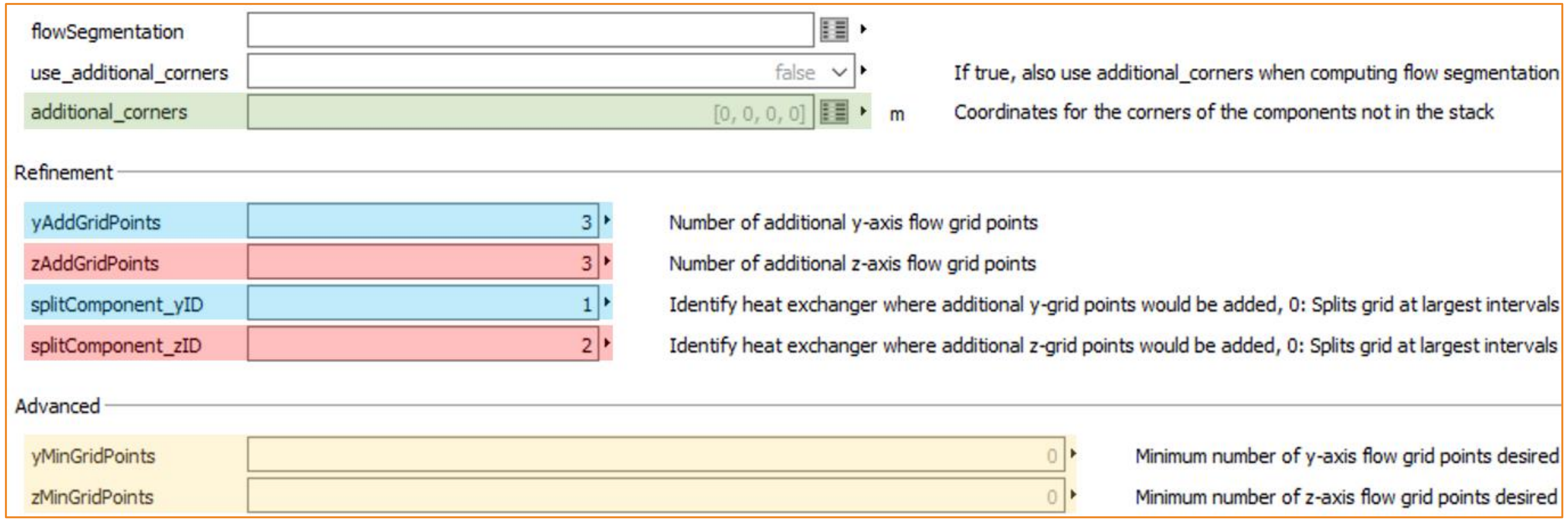
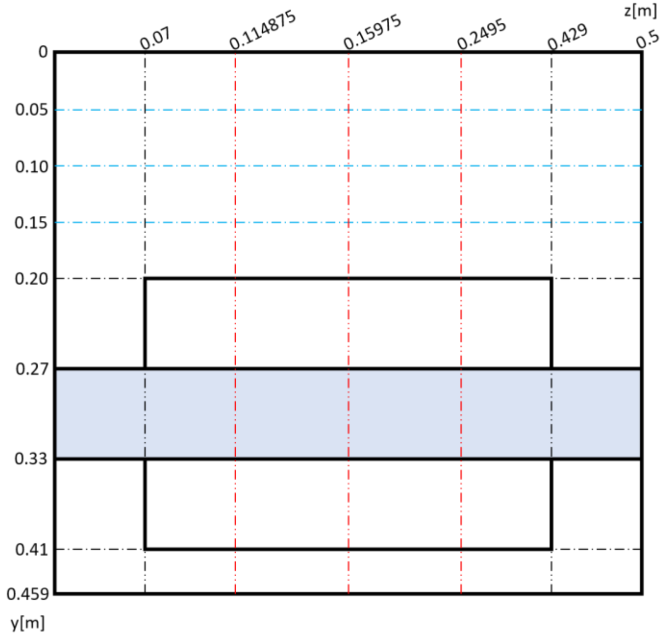
Stream Tubes

- Stream tube grid point 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





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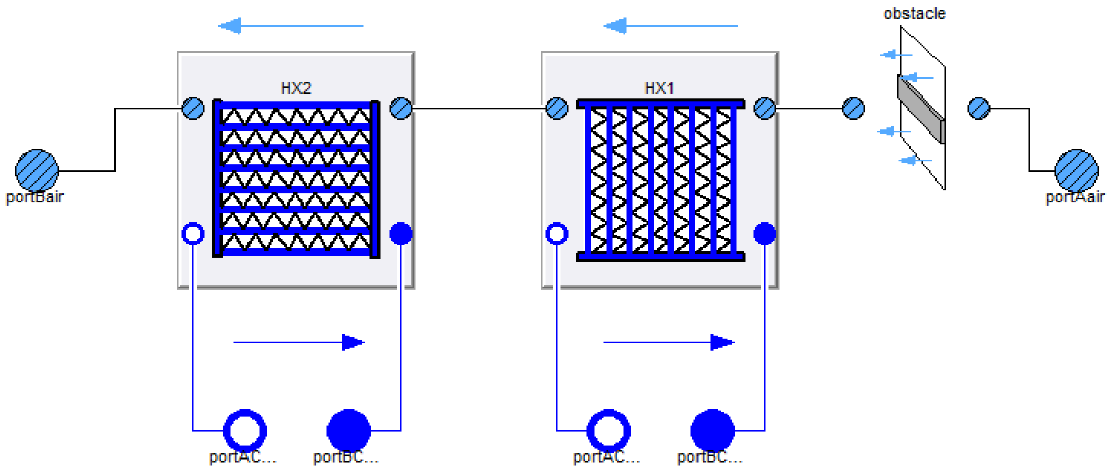
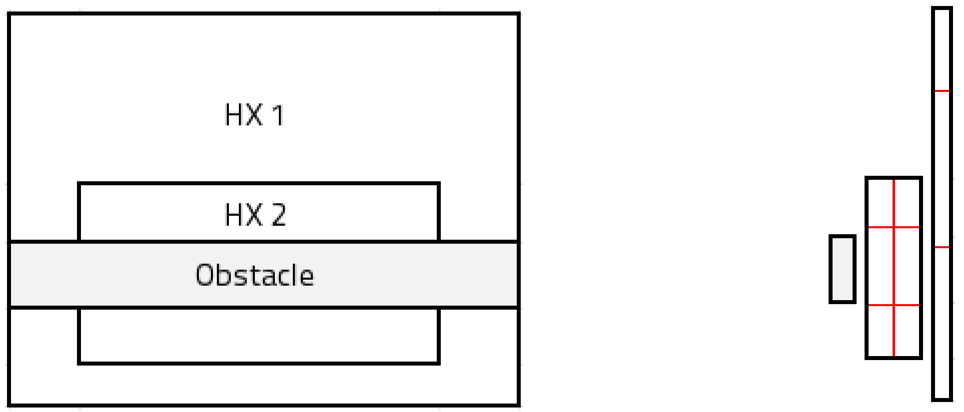
Stack

- 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

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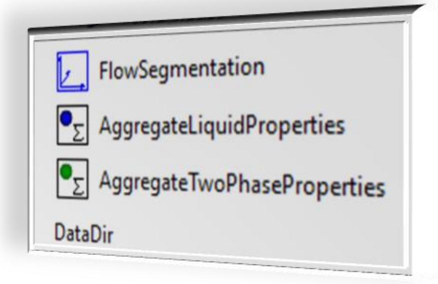
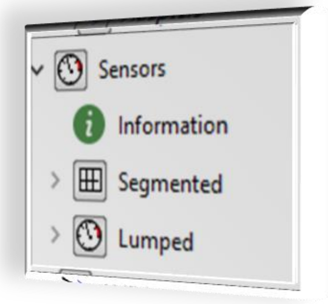
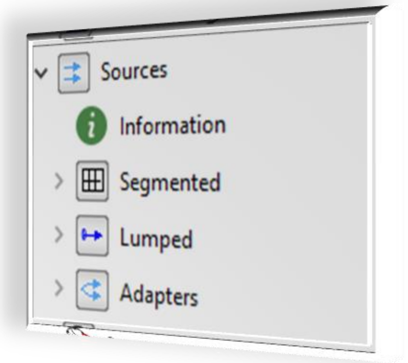
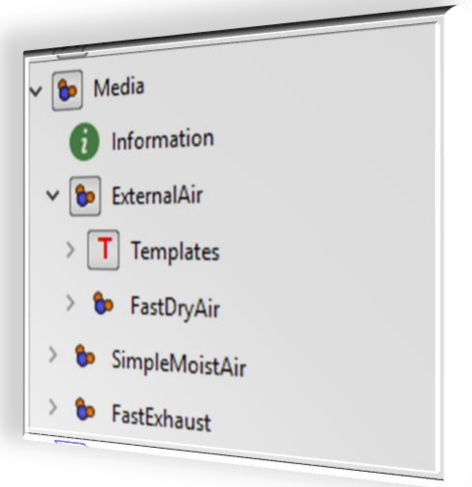
Media and other basic components









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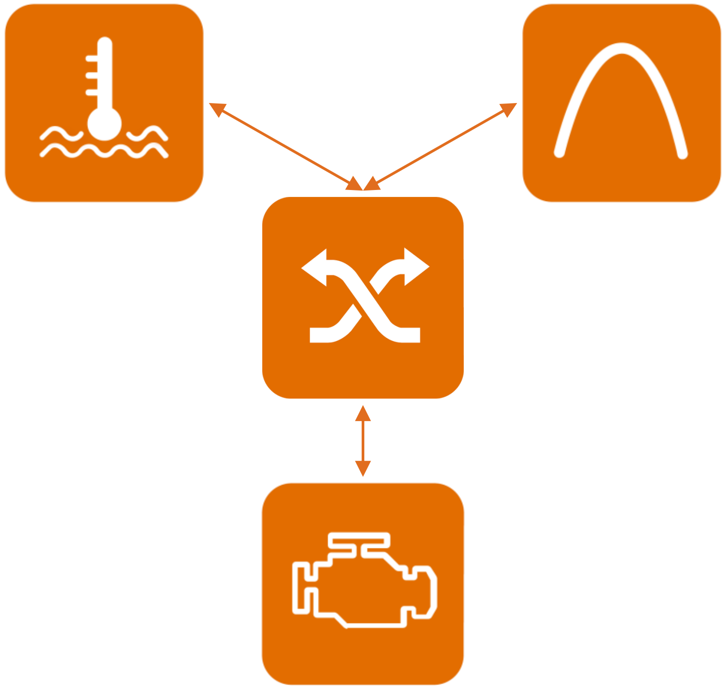
MODELON COMPATIBILITY

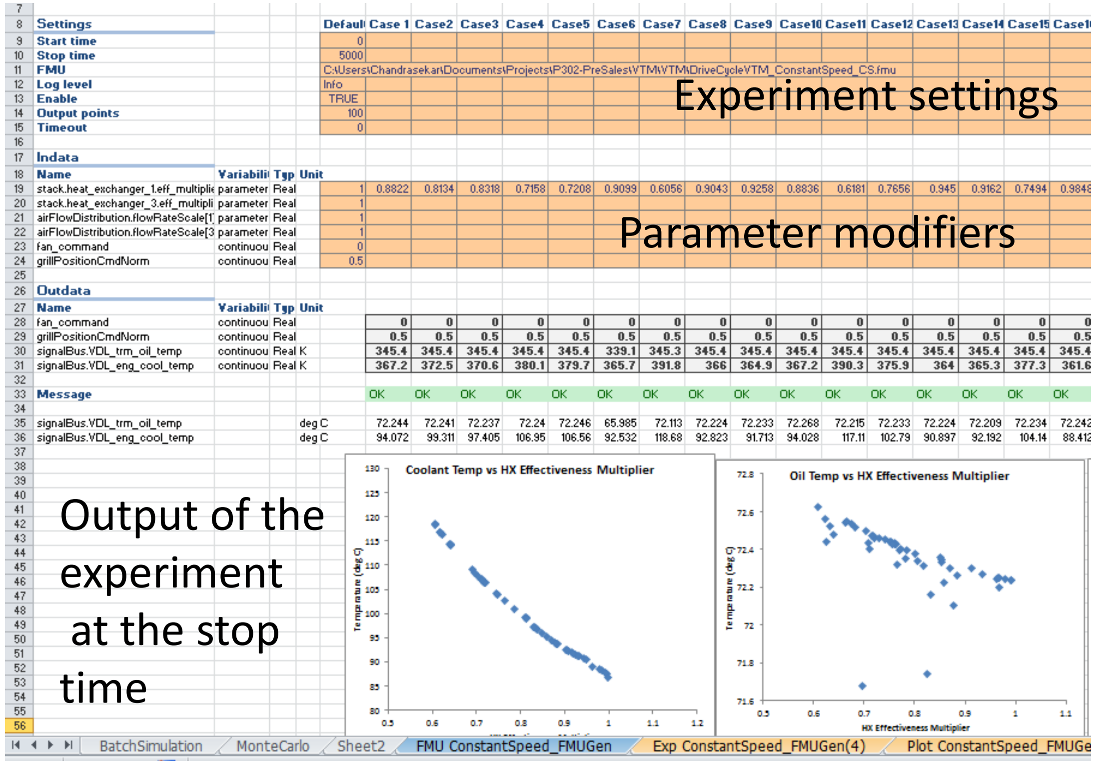
RECOMMENDED MODELON LIBRARY COMPATIBILITY

- 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)

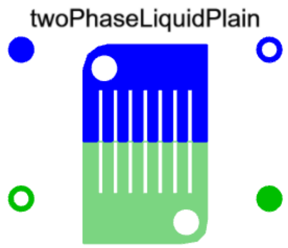


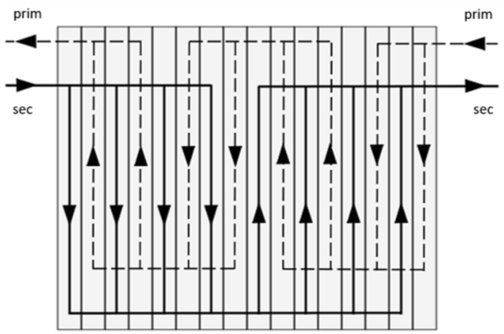
LATEST RELEASE

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