Heat Exchangers in ASPEN Plus
Introduce the unit operation models used for heat exchangers

Introduce the HeatX & MHeatX block

Model a shell and tube exchanger
Heat Exchanger Models

- **Heater** - Heater or cooler
- **HeatX** - Two stream heat exchanger
- **MHeatX** - Multi-stream heat exchanger
Heater

Heater performs these types of single phase or multiphase calculations:

- Bubble or dew point calculations
- Add or remove any amount of user specified heat duty
- Match degrees of superheating or subcooling
- Determine heating or cooling duty required to achieve a certain vapor fraction
The Heater block mixes multiple inlet streams to produce a single outlet stream at a specified thermodynamic state.

Heater can be used to represent:
» Heaters
» Coolers
» Valves
» Pumps (when work-related results are not needed)
» Compressors (when work-related results are not needed)

Heater can also be used to set the thermodynamic conditions of a stream.
Heater Input Specifications

- Allowed combinations:
  
  » Pressure (or Pressure drop) and one of:
    
    ➢ Outlet temperature
    ➢ Heat duty or inlet heat stream
    ➢ Vapor fraction
    ➢ Temperature change
    ➢ Degrees of subcooling or superheating
  
  » Outlet Temperature or Temperature change and one of:
    
    ➢ Pressure
    ➢ Heat Duty
    ➢ Vapor fraction
For single phase use Pressure (drop) and one of:

- Outlet temperature
- Heat duty or inlet heat stream
- Temperature change

Vapor fraction of 1 means dew point condition, 0 means bubble point
Heat Streams

- Any number of inlet heat streams can be specified for a Heater.

- One outlet heat stream can be specified for the net heat load from a Heater.

- The net heat load is the sum of the inlet heat streams minus the actual (calculated) heat duty.

- If you give only one specification (temperature or pressure), Heater uses the sum of the inlet heat streams as a duty specification.

- If you give two specifications, Heater uses the heat streams only to calculate the net heat duty.
Schematic:

Freon-12
10560 kg/hr
$T_i = 240 \text{ K}$
$P_i = 7.0 \text{ atm}$

Ethylene Glycol
$T_i = 350 \text{ K}$
$P_i = 2 \text{ atm}$

E-101

Freon-12
$T_o = 300 \text{ K}$

Ethylene Glycol
$T_o = 310 \text{ K}$

NRTL-RK
HeatX Model

- HeatX can perform simplified or rigorous rating calculations.

- Simplified rating calculations (heat and material balance calculations) can be performed if exchanger geometry is unknown or unimportant.

- For rigorous heat transfer and pressure drop calculations, the heat exchanger geometry must be specified.
HeatX Model (Cont’d)

HeatX can model shell-and-tube exchanger types:

» Counter-current and co-current

» Segmental baffle TEMA E, F, G, H, J and X shells

» Rod baffle TEMA E and F shells

» Bare and low-finned tubes
HeatX Model (Cont’d)

- **HeatX performs:**
  - Full zone analysis
  - Heat transfer and pressure drop calculations
  - Sensible heat, nucleate boiling, condensation film coefficient calculations
  - Built-in or user specified correlations

- **HeatX cannot:**
  - Perform design calculations
  - Perform mechanical vibration analysis
  - Estimate fouling factors
HeatX Calculation Modes

- **Shortcut**
  Performs simple material and energy balance calculations, and is used where geometry is unknown or unimportant. Can be used for design, rating and simulation calculations.

- **Detailed**
  Geometry needs to be specified. Can be used for rating and simulation calculations only.

- **Rigorous**
  Is used for design, rating, simulation and maximum fouling calculations. Integrates Aspen Plus with more detailed exchanger design/rating softwares.
HeatX Calculation Type

- **Design:**
  Area/Geometry is determined.

- **Rating**
  Determined whether given exchanger is over-designed or under-designed for a given duty

- **Simulation**
  Outlet conditions are predicted for inlet conditions

- **Maximum Fouling**
  Determined maximum fouling reached in an exchanger at which duty can be fulfilled
HeatX Input Specifications

- Select one of the following
  - Heat Transfer Area or Geometry
  - Exchanger Duty
  - Constant UA
  - For cold or hot outlet stream
    - Temperature
    - Temperature Increase/Decrease
    - Temperature Difference
    - Temperature Approach
    - Degrees of Superheat/Subcool
    - Vapour Fraction
HeatX Input Specifications

- Other inputs include:
  - Inside Shell diameter
  - Tube length, diameter (inner/outer), pitch, number
  - Baffle type, number, cut
  - Nozzle diameters for shell/tube
• Find area for above duty.
• Simulate for 25 sq.ft and find the exit temperature.
• Rate for 25 sq.ft.

Schematic:

Freon-12
10560 kg/hr
$T_i = 240 \text{ K}$
$P_i = 7.0 \text{ atm}$

Ethylene
Glycol
$T_i = 350 \text{ K}$
$P_i = 2 \text{ atm}$
98 Kmol /hr

E-101

Freon-12
$T_o = 300 \text{ K}$

NRTL-RK

Ethylene
Glycol
$T_o = 310 \text{ K}$
HeatX Example

- Cooling 100 lbmol of methanol (14.7 psia, 150 F) to 100 F using 3000 lbmol of water (14.7 psia, 50 F).
- Find area for above duty.
- Simulate for 155 sq.ft and find the exit temperature.
- Rate for 155 sq.ft.
- (Use RKS-BM property method)
Plots

- Plots can be made with variables heat duty, temperature, vapour fraction and pressure.
- Plots for both hot side and cold side can be plotted.
Exercise (Detailed Mode)

- Run the exchanger under detailed mode.
- Geometry to be supplied as:
  - Shell Diameter 3 ft, tube pass 1
  - 60 bare tubes, 15 ft length, pitch 31 mm, 21 mm ID, 25 mm OD,
  - 5 Segmental baffles, 15% cut
  - All Nozzles 100 mm

- Find the % over-design/under-design in rating mode
- Find the hot outlet temperature in simulation mode
Rigorous Mode

- More detailed and accurate design calculations can be carried out
- Separate Interface is also available
- Geometry is checked conforming to TEMA Standards
HeatX versus Heater

- Consider the following:
  
  » Use HeatX when both sides are important.

  » Use Heater when one side (e.g. the utility) is not important.

  » Use two Heaters (coupled by heat stream, Calculator block or design spec) or an MHeatX to avoid flowsheet complexity created by HeatX.
Objective:
Compare the simulation of a heat exchanger that uses water to cool a hydrocarbon mixture using three methods: a shortcut HeatX, a rigorous HeatX and two Heaters connected with a Heat stream.

- Hydrocarbon stream
  - Temperature: 200 C
  - Pressure: 4 bar
  - Flowrate: 10000 kg/hr
  - Composition: 50 wt% benzene, 20% styrene, 20% ethylbenzene and 10% water

- Cooling water
  - Temperature: 20 C
  - Pressure: 10 bar
  - Flow rate: 60000 kg/hr
  - Composition: 100% water
-- Start with the General with Metric Units Template.

-- Use the NRTL-RK Property Method for the hydrocarbon streams.

-- Specify that the valid phases for the hydrocarbon stream is Vapor-Liquid-Liquid.

-- Specify that the Steam Tables are used to calculate the properties for the cooling water streams on the Block BlockOptions Properties sheet.
HeatX Workshop (cont’d)

- **Shortcut HeatX simulation:**
  - Hydrocarbon stream exit has a vapor fraction of 0
  - No pressure drop in either stream

- **Two Heaters simulation:**
  - Use the same specifications as the shortcut HeatX simulation

- **Rigorous HeatX simulation:**
  - Hydrocarbons in shell leave with a vapor fraction of 0
  - Shell diameter 1 m, 1 tube pass
  - 300 bare tubes, 3 m length, pitch 31 mm, 21 mm ID, 25 mm OD
  - All nozzles 100 mm
  - 5 baffles, 15% cut
  - Create heat curves containing all info required for thermal design.
  - Change the heat exchanger specification to Geometry and re-run.
Exercise
Example

\[ \text{C}_6\text{H}_6 \quad + \quad \text{C}_3\text{H}_6 \quad \rightarrow \quad \text{C}_9\text{H}_{12} \]

Benzene + Propylene \rightarrow Cumene (Isopropylbenzene)

90\% Conversion of Propylene

Use the RK-SOAVE Property Method
Exercise

- Objective: Model the heat exchanged between the process and utility streams using a HeatX block – first in the Shortcut mode and then in the Detailed mode.

![Diagram of a process flow with nodes labeled FEED, REACTOR, HEATX, SEP, and PRODUCT with flow direction arrows and temperature annotations T = 20°C, P = 4 bar, 5000 kg/hr H₂O and T = 130°C].